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American Ferns—III. Our Genera of Aspidieae

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The natural arrangement of fern groups has too often suffered materially by the systematist insisting exclusively on this or that set of characters as primary in importance, to the neglect of others, whereas the sum of characters combined with habit would seem to result in a more natural system. John Smith, whose knowledge of ferns in cultivation probably exceeded that of any other man, emphasized as primary the character of the rootstock, separating those genera in which the stipes are articulated to the rootstock from those in which the stipes are continuous. On this basis *Phegopteris* and *Polypodium*, which at Kew are still kept in one genus, were distributed at opposite ends of the family. Presl and Fée emphasized venation, while Hooker disregarded both these series of characters except for sectional (or subgeneric) distinctions and made the presence or absence of an indusium and its form primary characters in the separation of genera. Mettenius and his followers in the later German school have quite largely disregarded most of these characters, and the recent treatment in Engler and Prantl, while more rational in several other tribes, passes all bounds in the Aspidieae in uniting under a single genus forms even more diverse than those that exist in some of the Hookerian aggregates.

It is clear that in the Aspidieae several series of characters must be taken into account, and the following would seem to be the arrangement in which they appear in the order of their relative weight:

1. Type of venation.

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2. Habit and growth characters of stem.
3. Position of sori in relation to veins.
4. Indusial characters.

The venation of the fern, forming as it does a part of the primary anatomical structure of the plant, must furnish characters which are subject to less variation than those which pertain either to the location of the sori on the veins or to the character of the indusial covering of the sorus, which at best is only a member of the epidermal system, normally a flattened trichome, and, like terminal or peripheral members generally, is subject to variation to a greater extent from external causes. While accidental conditions of united veins occur in certain free-veined species, and in certain genera there exist species closely related by habit and structure, in some of which the veins are normally free and in others the veins anastomose, still the characters of free or anastomosing veins follow, in general, very clearly defined types and can fairly be taken to represent one of the most fundamental elements in the determination of generic groups.

The determination of generic characters having been accomplished, the question of generic names is an entirely different problem. This is a direct corollary of the proposition that a genus is a group of related species. The botanists of the middle period of the last century proceeded without rule; priority was not considered, and in taking up names one followed one fancy, and another a wholly different one, which resulted in the same name being applied to widely different aggregates. Since the attempt has now been made to adjust nomenclature by rule rather than by individual fancy it has become necessary to fix upon certain species as generic types * with which the generic name will inseparably stand as valid

* The student of generic types should not be misled by the use of the term type in a wholly different sense. In *Historia Filicum*, for example, John Smith uses the term "type" in the sense of the most common or well-known species included in his conception of the genus, whether it formed a part of the genus as originally proposed or not. Thus his type of *Nephrodium* is *Aspidium molle* Swz., which was not a part of the genus as originally founded by Richard, and is generically distinct from any species it did contain. The "biological type" or center of variation and divergence is also a wholly different matter and one that can never be fully determined until after the last species of any generic group has been described. The nomenclatorial type is the one considered here and, so far, it has only been definitely settled that this type must be a species mentioned in connection with the original publication of the genus.

or pass into synonymy according as views of generic limitations become closer or more elastic. The consideration of the present tangle is respectfully commended to those who are following the *ignis fatuus* of determining generic types by the subsequent history of the genus—a principle only slightly removed from the "method of residues" which in its original form now seems to be wholly abandoned by even its former strenuous advocates. For early genera only the historic type on which a genus was originally founded can stand before the acceptance of the first named species under the genus as its nomenclatorial type. This applies to all genera but principally concerns genera founded while botany was in a formative period when generic limits were not clearly drawn. Where a type species was named, that of course must take precedence over everything. Monotypic genera cannot come into question as their sole species must be the type on which they were founded.

Attention is called to the Aspidieae at this time, since we have recently had presented to us a rearrangement * of our native species under generic names, two of which are utterly untenable on any system of nomenclature yet followed, except that of personal preference. And, what is still more remarkable, this proposition comes from one who in the past has most loudly proclaimed against change of any sort and yet would now attempt to introduce among our fern names one that has never before been used in America, and one which is without question the worst selection that could possibly have been made. It is impossible in the light of all the evidence at hand to interpret this new departure in any other way than as a deliberate result of prejudice and an unwillingness to adopt a course of action simply because it accords with the principles of the Rochester system. Nothing short of this could explain the willingness to do a wrong thing, when the right one would have been not only the only correct course, but a perfectly natural course to pursue. To see that such is the case we have only to lay bare the facts underlying the history of the group.

The species of the present tribe Aspidieae so far as known to Linnaeus were included with his genus *Polypodium*. Ten years after the publication of *Species Plantarum*, Adanson published the

* Rhodora, 4: 7–13. Ja. 1902.

first genus in the present alliance calling special attention to the distinctive character of the superior indusium which was perhaps the most obvious mark that distinguished the European Aspidieae from *Polypodium*. Not only was this distinction clearly defined, but he mentions in addition the type of the genus and refers to illustrations that are absolutely unmistakable. He says:

"DRYOPTERIS: Paquets de fleurs ronds, disposés sur 2 rangs sous chaque division des feuilles. Enveloppe enparasol. Globules environnés d'un anneau élastique." Familles des Plantes, **2**: 20. 1763.

And on page 551 (index) he adds:

"DRUOPTERIS Diosk. 20.
Filix mas *Fuchs, Tour. t.* 311, 312.
Fougere mâle Gall."

thus citing not only the origin of the name dating back to Dioscorides, but also the name used by the old herbalists, the authentic figures of Tournefort,* and the name then current in France, which like our own familiar male-fern is the name which the plant has borne for the last three centuries or more in northern central Europe, where it is the commonest member of this genus either wild or in cultivation. I cannot conceive of a more complete, direct, and explicit establishment of a generic name than this, and yet Mr. Davenport's only comment on this bit of history is that "a genus so ill-defined, with its type standing for one thing and its description for another, has no just claim for consideration as against the more clearly defined *Nephrodium* which has been in use for nearly a century." Surely we have here either an attempt to mislead those who do not have access to the original publications or a case of negligible ignorance of facts, either of which must stand in the same category of constructive error.

There being a definite genus established for our wood-ferns there is no necessity for another, but let us look a little farther into *Nephrodium* and discover if possible what this "more clearly defined" genus is. Richard, who edited Michaux's Flora, says:

"NEPHRODIUM. *Fructif.* Puncta in disco frondis sparsa seu seriata; primum obtecta membranula reniformi aut lunata, hinc (servato nexu laterali) dehiscente." Michaux, Fl. Bor. Am. **2**: 266. 1803.

* To those who do not have access to Tournefort's classic *Institutiones* it may be said that *t. 311* gives a clearly drawn figure of the upper third or so of a leaf of the male-fern showing the characteristic reniform indusia, and *t. 312* gives various details including a segment greatly enlarged with the same characteristics in stronger relief.

So much for his description. Now what are the contents of this clearly defined genus with their modern equivalents, for it should always be borne in mind that a genus is a group of related species, not a definition or a description. We cite the species in the exact order of publication:

1. *N. acrostichoides* = *Polystichum acrostichoides.*
2. *N. thelypteroides* = ?
   (= *Dryopteris Noveboracensis, fide* D. C. Eaton).
3. *N. marginale* = *Dryopteris marginalis.*
4. *N. punctilobulum* = *Dennstaedtia punctilobula.*
5. *N. bulbiferum* = *Filix* (*Cystopteris*) *bulbifera.*
6. *N. filix-foemina* = *Asplenium filix-foemina.*
7. *N. asplenioides* = *Asplenium filix-foemina.*
8. *N. cristatum* = *Dryopteris cristata.*
9. *N. tenue* = *Filix* (*Cystopteris*) *fragilis.*
10. *N. rufidulum* = *Woodsia Ilvensis.*
11. *N. lanosum* = *Cheilanthes lanosa.*
12. *N. Dryopteris* = *Phegopteris Dryopteris.*

Surely this is a parody on "a more clearly defined" genus, judging from the *mélange* which Richard, its founder, placed in it, containing among its twelve species representatives of no less than eight well recognized genera, now distributed among four distinct tribes! No comment is necessary, and we could only wish for our friend that he were one tithe as anxious to establish a rational basis for nomenclature as he is to antagonize the "Rochester advocates" at whatever cost of consistency or good judgment.*

In connection with Mr. Davenport's statement that *Nephrodium* has been in use for nearly a century, we might say, lest his state-

* As a further illustration of misleading statements that occur in works supposed to carry the weight of authority, the following comment on *Nephrodium* is cited from John Smith (*History Filicum*, 206–207): "This genus as originally characterized embraced species with both free and anastomosing veins, the technical character consisting in all having a reniform indusium. Schott restricted the genus to the species having anastomosing veins only." It is very probable that John Smith, like many another fern writer, never actually took the trouble to look inside Michaux's *Flora*, but assumed that because the great Hooker included both types in the genus that this was the condition in the original. Of the original twelve species described by Richard all are free-veined, and among the variety of indusia represented only two species have reniform ones and some have none at all!

ment should mislead the uninformed, that it has hitherto been used mainly at Kew, where their idea of its type (*Eunephrodium*) is entirely outside the range of even the diverse contents which its founder included in it; it has never been in use on the continent to include our north temperate wood-ferns and never at all in America since its foundation. *Dryopteris* was taken up by Schott and later by Asa Gray in the first edition of his *Manual*, and its use by Americans for the past decade has been practically unquestioned except by Mr. Davenport himself.

Another genus adopted by Mr. Davenport for our ferns is *Aspidium* of Swartz, which, by a sleight-of-hand performance unknown to any other advocate of the idea of a specific type for a genus, he lodges with *Aspidium trifoliatum* (*Polypodium trifoliatum* L.). Here again an insufficient examination of fern literature has placed him in a second error. We quote from a paper of Cavanilles published in 1799:

"TECTARIA: *Fructificacion* en puntos redondos, esparcidos, situados en la superficie posterior de la hoja. *Tegumento* umbilicado. *Abertura* casi circular. Exemplo de este género: Polypodium trifoliatum de Linneo." Anales de Historia Natural, * 1:115. D. 1799.

It will thus be seen that the plant called *Aspidium trifoliatum* by Swartz is the monotype of *Tectaria*, which is a well-marked generic group as even Mr. Davenport is forced to admit. *Aspidium*, on the other hand, which he takes up for this species, was not proposed until 1801,† when Swartz described it as follows:

"ASPIDIUM. *Capsulae* in puncta subrotunda sparsa digestae, *Indusiis* umbilicatis l. dimidiatis tectae." Schrader's Journal für die Botanik, 1800: 29. 1801.

Then follow some seventy or more species which Swartz combined in this genus and which are now variously distributed among several genera. The first six mentioned are:

1. *A. articulatum* = *Oleandra articulata*.
2. *A. pistillare* = *Oleandra neriiformis* Cav.
3. *A. trifoliatum* = *Tectaria trifoliata*.
4. *A. Lonchitis* = *Polystichum Lonchitis*.

* At the time of the publication of my "Genera of Ferns" I had not seen this rare series, of which a complete set containing a number of Cavanilles' papers is now in the library of the New York Botanical Garden. The above is therefore the corrected date for *Tectaria* and *Oleandra* as published in my earlier paper.

† Mr. Davenport appears to be in doubt about this date, but had he examined the title page he would have found it perfectly clear.

5. *A. mucronatum* = *Polystichum mucronatum.*

6. *A. falcatum* = *Cyrtomium falcatum.*

On the application of the principle of regarding the first named species as the type of a genus, a principle which Mr. Davenport *professes* to accept, *Aspidium* becomes a straight synonym of *Oleandra*, which had been proposed by Cavanilles (*l. c.*) two years before, on the same page as *Tectaria* and immediately following it. On the unique application of a sliding scale in the matter of determining the type of a genus, which Mr. Davenport *actually does follow*, the name *Aspidium* would replace the later *Cyrtomium* proposed by Presl in 1836. But no one will be likely to consider seriously a system so illogical as his, and on any rational count *Aspidium* must pass into synonymy by the side of *Nephrodium;* we may consider ourselves fortunate to be able to dispense with two such unnatural groups of species as these were when first organized, and thus consign them to a merited oblivion.

The opening years of the fourth decade of the nineteenth century found us then with the following genera now forming a part of the Aspidieae properly established, each one traceable to a distinct and indisputable type:

DRYOPTERIS Adans. 1763.	POLYSTICHUM Roth, 1800 (?)*
MENISCIUM Schreber, 1791.	DIDYMOCHLAENA Desv. 1811.
TECTARIA Cav. 1799.	DIPTERIS Reinw. 1825.

It will be interesting to note the subsequent history of the group, since the extensive formation of fern genera has occurred since 1830.

In 1834 Schott† commenced a series of studies on genera, among which the following were considered:

ASPIDIUM, taken up for the species, *A. trifoliatum* Swz.

NEPHRODIUM, taken up for such species as *N. unitum*, *N. molle*, etc. This laid the foundation for the misconception of *Nephrodium* for species with connivent veins, and the application of the name to a group of species distinct from any originally in the genus.

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* As already noted (Mem. Torrey Club, **6**: 262. 1899) there is still uncertainty of the date of publication of Roth's third volume. With a preface dated 14 Sept. 1798, and a title page dated 1800, we have some of his genera cited in papers published in 1799.

† Genera Filicum, 1834.

POLYSTICHUM Roth.
DRYOPTERIS Adans.
THELYPTERIS, adopted for *Aspidium Thelypteris* (L.) Swz and its allies.
MENISCIUM Schreb.

Unfortunately Schott's studies were not systematized and were cut short by his death; several of the above genera even appear only in his "Observationes," a series of notes appended to his discussions and illustrations of genera.

It was Presl, however, who, in 1836,* commenced the process of generic expansion by founding a considerable number of new genera and adopting several older ones. His system was as follows:

ASPIDIACEAE

Nephrodiarieae
LASTREA Bory.†
OLEANDRA Cav.
NEPHROLEPIS Schott.
NEPHRODIUM Schott.

Aspidiarieae
POLYSTICHUM Schott.
PHANEROPHLEBIA Presl.
CYCLODIUM Presl.
CYRTOMIUM Presl.
SAGENIA Presl.
ASPIDIUM Schott.
DIDYMOCHLAENA Desv.

Presl cites Schott for several genera earlier named, thus recognizing the fact that he was using them in a sense different from that of their original authors.

Among his new genera was *Phanerophlebia* (p. 84) founded on *P. nobilis* (Schlecht.) to which must be joined *Amblia* (p. 184) which was founded on *A. juglandifolia* (H. & B.) on the misconceived notion that this species had no indusium.‡

Cyclodium (p. 85) was based on three species of the old world, of which *C. glandulosum* (Bl.) was first named, although *C. meniscioides* (Willd.) is perhaps better known. *Cyrtomium* (p. 85) was based on two old-world species, of which *C. falcatum* (L.) is not only the first named but is the long known plant common in

* Tentamen Pteridographiae. Prag, 1836.

† *Lastrea* contained three sections, the first of which was called *Dryopteris* but singularly did not contain the type species of Adanson's *Dryopteris* (*D. filix mas*) which instead was placed in *Thelypteris*.

‡ John Smith carelessly remarks (*Historia Filicum*, 204) "these two genera being evidently founded on specimens off which the indusium had fallen." This is true of *Amblia* but Presl (*l. c.*) says in establishing *Phanerophlebia*: "*Indusium orbiculare, peltatum.*" It is not always safe to trust the statements of the "authorities" and in taking up fern names it is often as essential to know fern literature accurately as it is to be familiar with growing ferns.

cultivation. *Sagenia* (p. 86) was founded on six species of which *S. lobata* (Rich.) is first named.

The non-indusiate species forming what has been known as *Phegopteris* (in its later Mettenian sense) were left by Presl with *Polypodium* in a distinct tribe. The free-veined species he left under *Polypodium*, where they had been placed by Linnaeus, but in a distinct section which he named *Phegopteris*. The old complex genus *Polypodium* was dismantled for the first time on the rational basis of venation, and among the aspidioid types, the genera *Goniopteris* and *Dictyopteris* were founded. *Goniopteris* (p. 181) was based on nine species, of which *G. incisa* (Swz.) was first named, and *Dictyopteris* (p. 194) was founded on four species, of which *D. attenuata* (R. Br.) was mentioned first; the last named genus is exclusively an old-world group, so need not be considered further here. *Pleocnemia* (p. 183), another old-world group, was also established, based on *P. Leuceana* (Gaud.) of the East Indies. *Meniscium* Schreb. was properly accepted, but appears under a third tribe (Grammitaceae) because of its elongate sori.

Link * was the next to divide the genera. His arrangement was as follows:

ASPIDIUM.	TECTARIA.
CYCLOSORUS.	BATHMIUM.
NEPHRODIUM.	DIDYMOCHLAENA.
POLYSTICHUM.	

Of these, *Aspidium* was taken up for the species with a reniform indusium and free veins (= *Dryopteris*). *Nephrodium* was taken up for what Schott had named *Nephrolepis*, thus shifting the name in still a new direction beyond the range of the eight genera *Nephrodium* originally contained! *Tectaria* was adopted as a genus but was shifted to the group containing *Aspidium coriaceum* (Swz.), a species later included by Cavanilles in this genus; for *Tectaria trifoliata*, however, which was the sole type of its genus as founded, and its allies, Link proposed a new genus *Bathmium* (p. 114).† He also proposed *Cyclosorus* (p. 108) based on *C. gonglyodes*

* Filicum species in hort. reg. bot. Berol. cultae, 1841.

† This name was first proposed by Presl as a subgenus of *Aspidium* for the group containing *Aspidium Singaporanum* Wall. (= *Podopeltis* Fée). Link included also species of *Sagenia* Presl in *Bathmium*, making a new genus include an older one!

(Schk.) a fern from Guiana which Moore reduces to a synonym of *Nephrodium unitum*. *Cyclosorus* appears to be the first name definitely applied to a member of the group with connivent veins and cordato-reniform indusia (the § *Eunephrodium* of *Synopsis Filicum*).

Presl included the species of *Phegopteris* in *Polypodium*, but *Goniopteris* was kept distinct.

In 1841 John Smith * established the genus *Leptogramma*, based on seven species, of which *L. asplenoides* (Swz.) was first named. This genus, which has been placed by the Hookerian school in that monstrously incongruous group known as *Gymnogramme*, differs from *Phegopteris* solely in the possession of elongated sori and in any natural system must stand next to *Phegopteris* if not united with it.

In 1842 Hooker and Bauer established the genus *Fadyenia* † based on the single species known from Jamaica. In this work, *Genera Filicum*, the Preslian genera were largely taken up and this publication represents the most sane and sound pronouncement that ever emanated from Kew on the subject of the classification of ferns. More species of ferns by far have been described from Kew than from any other center of study in the world, but since the publication of *Genera Filicum* in 1842 their utterances on general fern classification have lapsed into a harmless *laissez faire* policy a half century behind the times, and a much greater amount behind their magnificent opportunities in herbarium and conservatory equipment and facilities.

In 1846 John Smith ‡ further established the genus *Cyclopeltis*, based on a single West Indian species. His early views on genera quite closely coincided with those of Presl and his opinion of relationships merits particular attention since he knew growing ferns in cultivation probably better than any man who has ever lived. His later views on this group as expressed in *Historia Filicum* (1875) may be tabulated as follows (the exclusively old world genera in Roman type and those with American species in small capitals):

* Hook. Journ. Bot. **4**: 51. 1841.

† Genera Filicum, *pl. 53B*. 1842.

‡ Bot. Magazine, 1846.

Phegopterideae.

- Stegnogramme Blume (1828).
- Goniopteris Presl.
- Dryomenes Fée.*
- Amphiblestra Presl.†
- Dictyopteris Presl.
- Dipteris Reinw. (1825).

- Hypoderris R. Br. (1830).
- Trichiocarpa J. Sm.
- Podopeltis Fée.‡
- Aspidium (incl. *Sagenia*).
- Cyclodium Presl.
- Cyrtomium Presl. (incl. *Phanerophlebia*).
- Pleocnemia Presl.
- Nephrodium Schott.
- Mesochlaena R. Br.⁂
- Fadyenia Hook.

- Lastrea Presl.
- Polystichum Schott.
- Acrophorus Presl.‖
- Adenoderris J. Sm.¶

- Arthropteris J. Sm.**
- Cyclopeltis J. Sm.
- Nephrolepis Schott.

Isoloma J. Sm.††

Didymochlaena Desv.

Struthiopteris Willd.

- Leptogramma J. Sm.
- Phegopteris Fée.
- Hypolepis Bernh. (1806).

In 1850–1852 Fée published his *Genera Filicum* in which this tribe appears as follows:

Cyclodieae

- Polystichum Roth.
- Phanerophlebia Presl.
- Hemicardion Fée.
- Amblia Presl.

Cyclodium Presl.

- Cyrtomium Presl.
- Podopeltis Fée.
- Bathmium Link.

Aspidieae

- Aspidium Swz.
- Cystopteris Bernh.
- Lepidonevron Fée.
- Dichasium A. Br.‡‡

Oleandra Cav.

- Nephrodium Rich.
- Haplodictyon Presl.
- Abacopteris Fée. ⁂

- Pleocnemia Presl.
- Sagenia Presl.
- Phlebogonium Fée.
- Cardiochlaena Fée.
- Fadyenia Hook. & Bauer.

Besides *Nephrolepis* and other genera now placed in Davallieae.

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* Founded on *Polypodium menisciicarpon* of Blume, but extended by Smith to include *P. plantagineum* L. They represent the non-indusiate type paralleling *Tectaria*.

† Based on *Pteris latifolia* H. & B.

‡ To the type named by Fée, Smith adds a second species, *P. sinuata*.

⁂ Horsefield, Plantae Jav. rariores, 1838; based on *Polypodium villosum*.

‖ Based on *Aspidium nodosum* Blume of the old world.

¶ Based on *Aspidium glandulosum* Hook. & Grev. of the West Indies.

** Based on *Polypodium tenellum* Forst., of New Zealand.

†† Based on *Lindsaea lanuginosa* Wall.

‡‡ This was based on *Aspidium Donianum* Spreng. and was proposed by A. Braun (Flora, **24**: 710. 1841) as a subgenus. Fée was, I think, the first to suggest generic rank for it (p. 302).

⁂ Congr. Sci. de France **1**: 178. 1843, based on *A. Philippinarum* Fée.

In the above arrangement Fée took several untenable positions and was perhaps inclined to increase genera unduly on which we would comment as follows:

1. *Phanerophlebia* and *Amblia* were both maintained following Presl's earlier misconception (*cf. supra*).

2. *Hemicardion* was substituted for *Cyclopeltis* J. Sm. and was based on the same monotype. This was not due to ignorance of the fact of an earlier genus, for he cites Smith's work; it must be set down as a case of deliberate misappropriation of a genus, of which botanical literature is unfortunately too full of conspicuous examples.

3. In *Nephrodium*, as used by Fée, none of the original species were mentioned but it was confined to the species with connivent veins.

4. *Aspidium* was used for the free-veined species with cordato-reniform indusia (= *Dryopteris* Adans.), thus following Link.

5. *Bathmium* Link was taken up for *Tectaria trifoliata* and its allies.

6. Besides *Hemicardion* the following genera were established:

PODOPELTIS (p. 286) based on a single species, *P. Singaporiana* (Wall.). This has usually been united with *Tectaria*.

CARDIOCHLAENA (p. 314) based on several species of which *C. alata* from the Philippines is first named. This has usually been referred to *Sagenia*.

LEPIDONEVRON (p. 301) based on numerous species with the indusium adnate at the base and with pendulous leaves; the first named species is *L. bidentatum* (Presl); the genus is usually referred to *Nephrolepis*, and hence belongs outside the tribe under consideration.

PHLEBIOGONIUM (p. 314) based on *P. impressum* (Griffith), an old-world species.

The non-indusiate series were still kept with the Polypodieae; *Goniopteris* and *Dictyopteris* were retained, and *Phegopteris* of Presl was raised to generic rank (p. 242), *Polypodium Phegopteris* L. being properly named as the first and consequently type species.

In 1856 Mettenius * capped the climax of conservatism, and practically abandoned all structural characters except for sectional

* Filices hort. bot. Lipsiensis, 1856.

limitations combining all the genera of this series into *Aspidium* and *Phegopteris*, the former containing the indusiate and the latter the non-indusiate species regardless of vein characters or habit. Christ in 1897 * followed his lead but included also *Fadyenia* Hook. & Bauer in the *mélange*.

During the next year Moore † published a synopsis of ferns which in general approximated those of Presl and Fée but differed in a number of features particularly in the inclusion of *Phegopteris* in *Polypodium*, a practice to which all Englishmen except John Smith seem to have been unfortunately addicted. Moore's arrangement is as follows :

Polypodieae.
- POLYPODIUM (incl. *Phegopteris*).
- GONIOPTERIS.
- DICTYOPTERIS.
- DIPTERIS.

Aspidieae.
- ASPIDIUM (adopted for *Bathmium* Link *p. p.*, and *Podopeltis* Fée).
- CYRTOMIUM (incl. *Phanerophlebia*).
- CYCLODIUM.
- POLYSTICHUM (incl. *Cyclopeltis*).
- FADYENIA.
- SAGENIA.
- PLEOCNEMIA.
- NEPHRODIUM (veins connivent).
- LASTREA (veins free).
- OLEANDRA.
- NEPHROLEPIS.

The arrangement of Hooker ‡ is well known. *Polypodium* was retained in its Swartzian sense regardless of habit or venation and consequently contained such strange bedfellows as *Phegopteris*, *Goniopteris*, *Dictyopteris*, and *Dipteris* besides the whole array of eremobryoid species; *Aspidium* was taken up for the centrally peltate indusiate species of whatever type of venation and habit, and *Nephrodium* was similarly taken up for those species with a cordato-reniform indusium; in the last genus, § *Lastrea* contained the free-veined species, § *Eunephrodium*, the connivent-veined species, while the species with anastomosing veins were distributed among the sections *Sagenia* and *Pleocnemia*. *Didymochaena*, *Fadyenia*, and *Meniscium* were also maintained. As stated above, generic limitations at Kew have never represented natural genera, and yet having been popularized in such a general work as *Synopsis Filicum* they have had an influence probably wider than any other system

* Die Farnkräuter der Erde, 1897.

† Index Filicum, lxxxi–xc. Ap. 1857.

‡ Species Filicum, 4 : 5–150. 1862. Also Synopsis Filicum, 1874.

proposed, having been followed in the arrangement of herbaria and for tentative works by minor botanists the world over as a matter of convenience.

To give a telling example of the great range of nomenclatorial changes undergone by any particular species it is only necessary to follow the type of Adanson's genus *Dryopteris* through its various vicissitudes.

POLYPODIUM FILIX-MAS L., 1753, was placed in DRYOPTERIS by Adanson 1763, Schott 1834, Asa Gray, 1848, and Otto Kuntze, 1891; in ASPIDIUM by Swartz 1801 and 1806, Link 1841, Fée 1850–1852, Mettenius 1856, D. C. Eaton 1867, and Christ 1897; in LASTREA by Bory 1824, Presl 1836, Moore 1857, and John Smith 1875; and in NEPHRODIUM by Hooker 1862 and 1874.

Nephrodium as a genus has likewise had strange vicissitudes since its establishment for a grand *mélange* of American species in 1802. In 1834 Schott took it up for the connivently anastomosing veined species with cordato-reniform indusia in which he was followed by Presl 1836, Fée 1850–1852, Moore 1857, and John Smith 1875. Hooker 1862, also recognized this group as constituting the true *Nephrodium* type of his more comprehensive genus. In 1841 Link transferred the name to what Schott had called *Nephrolepis*. In 1852 Hooker gave the genus a wider significance so as to cover all species with cordato-reniform indusia.

In limiting *Nephrodium* to the free-veined species it will be seen that Mr. Davenport is following an entirely new lead and his statement that *Nephrodium* has been in use for nearly a century thus loses practically all of its force. In the sense in which he proposes it, it has never been used anywhere, and the attempt to bring it into use at this time is as reprehensible as it is uncalled for and irrational.

Aspidium as a genus has had a still more varied history. In 1834 Schott limited it to *Tectaria* and in this he was followed by Presl in 1836 and by Moore in 1857. John Smith in 1877 combined *Sagenia* with this giving the genus a wider range of characters. In 1841 Link limited the name to species with a cordate indusium and free veins thus making it synonymous with *Dryopteris*. In this he was followed by Fée in 1850–52. In 1862 Hooker took up the name for all forms with a peltate indusium irrespective of

the venation. In 1856 Mettenius went back to the Swartzian use of the genus including in it practically everything with a superior indusium; in this he was followed by D. C. Eaton in our own country, and by Dr. Christ of Basel.

After this *résumé* of migration and shifting of generic names and limits, if there be anyone who still supposes that the application of fern names in the past seventy years is a subject in which there has been any considerable degree of unanimity among the "authorities," or who still doubts the desirability and necessity of anchoring generic names to some fixed specific type in accordance with some rational principle, he is surely too blind to read history, or too slow to be worth waiting upon longer to make up his mind.

The ferns of our own country alone, or of the North Temperate zone even, do not form a sufficient series to enable one to judge clearly or logically in regard to true generic limitations. It is necessary to consider a wider range of species for this purpose. The following genera which are represented in America appear to us worthy of being retained; it will be seen that only three of these are represented in our Northern States. Certain extra-limital genera are also included to round up the system, and these representatives of the old-world flora are printed in italics, those of the American flora appearing in small capitals. Space forbids more than the briefest characterization here as follows:—

Veins normally free, simple, forked, or pinnately branched.
- Indusium normally absent.
  - Sori more or less elongate. — LEPTOGRAMMA J. Sm.
  - Sori round, punctiform.
    - Margins of segments plane, herbaceous. — PHEGOPTERIS Fée.
    - Margins of segments widely inflexed, membranous. — PLECOSORUS * Fée.
- Indusium orbicular, centrally peltate.
  - Pinnae continuous with the rachis; texture firm, more or less coriaceous. — POLYSTICHUM Roth.
  - Pinnae articulated with the rachis, easily caducous; texture thin herbaceous. — CYCLOPELTIS J. Sm.
- Indusium oval, attached by a central axis to a thickened linear receptacle. — DIDYMOCHLAENA Desv.
- Indusium cordato-reniform, attached by the sinus.

* *Plecosorus* was established by Fée (Gen. Fil. 150. 1850–52) on *Cheilanthes speciosissimus* A. Br., which the Kew writers have retained in *Cheilanthes*.

Leaves simple, pedate; veins obscure. CAMPTODIUM † Fée.
Leaves compound, pinnate; veins distinct. DRYOPTERIS Adans.
Veins pinnate, usually uniting into simple areolae especially toward the outer margin, atypically free. PHANEROPHLEBIA Presl.
Veins connivent, *i. e.*, the branches from contiguous pinnate groups uniting to form one or more arches.
Indusium normally absent.
Sori round, punctiform. GONIOPTERIS Presl.
Sori elongate on the more or less parallel transverse arches. MENISCIUM Schreb.
Indusium cordato-reniform, attached by the sinus. CYCLOSORUS ‡ Link.
Indusium oblong, attached longitudinally by the center. *Mesochlaena* R. Br.
Indusium orbicular, centrally peltate. *Cyc odium* Presl.
Veins forming a single row of areolae next the midrib with free included veinlets; indusia elongate-cordate; leaves simple. FADYENIA Hook. & Bauer.
Veins copiously anastomosing.
Indusium normally absent.
Leaves bipartite, the main veins dichotomous. *Dipteris* Reinw.
Leaves pinnate. *Dictyopteris* Presl.
Indusium orbicular, centrally peltate.
Areolae regular, with the included veinlets straight and directed towards the margins of the segments. *Cyrtomium* Presl.
Areolae irregular, fine, the included veinlets often branched and recurrent. TECTARIA Cav.
Indusium cordato-reniform, attached by the sinus. SAGENIA Presl.

In the above synopsis we have not included a series of extra-limital genera like *Luerssenia* Kuhn and *Cheiropteris* Christ of comparatively recent foundation, nor some of the older genera like *Pleocnemia* Presl, which are likewise extra-limital. The aspidioid generic groups which in *Synopsis Filicum* are wrongly bound up in the genus *Acrostichum* may form the subject of a later paper in the present series.

COLUMBIA UNIVERSITY, 24 February 1902.

† *Camptodium* was established by Fée (Gen. Filicum, 298. 1850–52) based on *Aspidium pedatum* Desv., an anomalous member of the group in habit and structure found in the West Indies.

‡ *Cyclosorus* Link, 1841, appears to be the first name correctly applied to a member of the group of species with connivent veins and cordato-reniform indusia It represents the section *Eunephrodium* of *Synopsis Filicum* which followed the error started by Schott in 1834 in making *Nephrodium* stand for a group of species that its founder never included within its limits.

Studies on Urnula and Geopyxis

By Elsie M. Kupfer

(With Plate 8)

The apparent confusion in which the genus *Urnula*, as treated by various authors seemed to stand, and the belief that an examination of the anatomical structure might lead to some conclusions as to the relationships of the various species included under this name, led the writer to the present investigation. The results reached in the paper are threefold: (1) The reëstablishment of the genus *Urnula* upon its proper footing; (2) The determination of the relationship of the genera *Geopyxis* and *Urnula;* and (3) The establishment of a new genus *Chorioactis* allied to *Plectania* in the family Pezizaceae.

The excellent work of Dr. E. J. Durand on the Pezizineae has laid down the lines which investigation in such work must take; and it was the purpose of the writer to follow as closely as was feasible Dr. Durand's plan and method. Of necessity, the study was made entirely from dried material, which, while satisfactory in most respects, left something to be desired in one or two instances. The specimens were soaked up for a day in a mixture of equal parts of glycerine, alcohol, and water, then dehydrated and embedded in paraffin. The sections 3–10 μ in thickness were taken from the center of the cup, and were stained with haemalum. The tissue drawings were outlined with a camera lucida.

The genus *Urnula* was founded by Fries in 1849* on *Peziza Craterium* Schweinitz.† Fries' description of the genus was as follows: "*Excipulum coriaceum, inflatum, inane, clausum dein ore rotundo rimose dehiscens. Discus latera interiora vestiens sporis moniliformi-seriatis intermixtis paraphysibus superficiales byssisedae.*" Although the characters noted by Fries are, naturally, mainly external, there can be no doubt as to the limitation of the genus, since Fries mentions the type on which he originated it, which since the publication of Schweinitz' figure has been well known.

* Summa Veg. Scand. **2**: 122.

† Syn. Fung. Car. sup. 9. *pl. 1. f. 7–11.*

During the next forty years three additional species were placed in the genus—*U. minor* Fries, 1855, from Guinea, *U. Hartii* Berk. from Greenland and *U. Microcrater* (Hazs.), from Hungary. As no material representing these species was available they are left out of consideration in the present article.

In 1889 Saccardo compiled descriptions of the existing species and added as a fifth, *U. terrestris* (*Podophacidium terrestre* Niessl). Saccardo's description of the genus was broad enough to include all five species.*

Rehm in his " Discomycetes " 1896 † perceiving a lack of relationship among the species of Saccardo, did what must be considered an utterly unwarranted step. Taking away from *Urnula* the type *Urnula Craterium* on which Fries had founded the genus, he reserved the generic name for the single species, *U. terrestris*, apparently unrelated to the former fungus ; so that Rehm has a genus *Urnula* consisting of a single species which has no resemblance to the type of Fries, and which accords in but a very general way with the Friesian description. *Urnula Craterium* he transfers to *Geopyxis*. It may be mentioned here parenthetically, that Lindau's treatment in Engler-Prantl ‡ need not be specially considered as he has adopted almost entirely Rehm's views and classification.

A letter to Dr. Rehm asking the reason for his transfer received a somewhat unsatisfactory reply. He answered that *Urnula Craterium* was placed with its *related species* under *Geopyxis*, because *Geopyxis* was established by Persoon before *Urnula* by Fries ; and that in order to retain the genus *Urnula*, under which Saccardo had placed *Podophacidium terrestre* of Niessl, he (Rehm) restricted the genus to this latter fungus. The two most essential points, however, were not answered. Why *Urnula Craterium* should be regarded as allied to *Geopyxis*, or why, except that Saccardo had placed it there, *Podophacidium terrestre* should be considered an *Urnula* are points left unexplained. On this latter point, indeed, Rehm has now serious doubts as will appear later ; so that his present opinion seems to be that the genus *Urnula* must disappear entirely.

* Sylloge Fungorum, **8** : 548 *seq.*

† Rabenhorst, Krypt. Flora, **1** : 971.

‡ Die natürlichen Pflanzenfamilien, **1** : 172–242, 253.

The genus *Geopyxis* was, as Rehm says, originated before *Urnula*. Persoon established it as a subgenus of *Peziza* about 1822.* As I understand his arrangement (which is somewhat obscure owing to errors in the synopsis), Persoon included forty-three species under the group *Geopyxis*. Of these, five, *G. carbonaria*, *G. micropus*, *G. bufonia*, *G. Catinus* and *G. verrucosa* still remain in the genus as described by Rehm. A comparison, then, of one of these forms with *Urnula Craterium* should show in how far the latter is allied to *Geopyxis* and by what right Rehm has placed Schweinitz' plant in this genus. For the purpose of this comparison *G. carbonaria* was chosen.

We have then to consider, by a study of external structure and internal anatomy, the relationships of these various fungi, *Gropyxis carbonaria*, *Urnula Craterium*, and *Urnula terrestris*. One other will come up for consideration. In 1891 Professor Underwood discovered a new fungus in Austin, Texas, which was sent to Professor Peck for identification. Peck described this in the forty-sixth report of the state botanist as *Urnula Geaster*. A doubt suggested by Professor Underwood as to the correctness of this generic reference was the direct occasion of this study, which was carried on under his guidance.

1. *Geopyxis carbonaria* (Alb. & Schw.)† is a small, fleshy fungus yellowish in color, and, at the most, 2 cm. in diameter. It is short-stalked, the stalks being 1–1.5 mm. long and 1–2 mm. wide. It is well figured in Cooke's Mycographia *pl. 74, f. 284*. An examination of the internal anatomy of *G. carbonaria* (*pl. 8, f. 1*) shows it to be a true member of the Pezizaceae and of *Geopyxis* according to Durand. The excipulum is entirely pseudoparenchymatous, the asci form a uniform layer, the stem is short and externally even—all of which points correspond to Durand's synopsis of this family and genus. In this *Geopyxis* the hypothecium is not particularly differentiated from the excipulum except by the smaller size of the cells. At the limiting border of the excipulum there are thicker walled cells, slightly darker in color. The cells of the excipulum average 14 μ in diameter; those of the hypothecium, 9 μ. The asci are about 170 μ long and 7–8 μ wide. The spores are 10–11 μ long and 3–4 μ wide.

* Mycol. Europaea, 1: 224–242.

† Conspectus Fungorum in Lusatiae sup. 314. *pl. 5. f. 2.* 1805.

2. *Urnula Craterium* (Schw.) Fr. (*Geopyxis Craterium* Rehm.) This is a large leathery fungus 3–7.5 cm. wide, often over 7 cm. high, with a stalk 5 cm. long and sometimes 2 cm. broad. Even externally the fungus does not closely answer Rehm's own description of the genus *Geopyxis* under which he places it; the texture of the apothecium is described as fleshy, the stem, as short and sometimes thin; while in this plant, the leathery character of the cup and the length and thickness of the stem are its noticeable features; one of its most characteristic points is the dense black tomentum which serves as a hypothallus. The hypothallus in *G. carbonaria*, on the other hand, is very inconspicuous. The difference in the size of the asci and spores is also a point worthy of mention in the contrast between the two forms; the asci in *U. Craterium* are 430 μ long and 12 μ wide; the spores, 25–30 μ long and 8 μ wide. The asci in this fungus then are more than twice as long and the spores nearly three times as large as in the *Geopyxis*. But ignoring these facts, a comparison of the internal anatomy of the two forms will, I think, dispel all illusions as to their relationship. In *fig. 2* is represented a cross section of *U. Craterium*. The excipulum is seen to be divided into two distinct layers. At the outside, next to the limiting membrane, there are a few rows of rather regular polygonal cells; but the great mass of the excipulum and hypothecium is prosenchymatous, *i. e.*, made up of long non-septate interwoven hyphae giving an exceedingly fibrous appearance to the whole tissue. The hypothecium is differentiated from the medullary portion of the excipulum by the closer mesh and smaller diameter of the hyphae of which it is composed. It is about one fourth the width of the whole sterile part.

Urnula Craterium, then, belongs to a totally different genus from *Geopyxis carbonaria* and must be restored as the type of the genus *Urnula* as Fries founded it. Indeed there are very strong reasons, as will be seen shortly, for placing it in an entirely distinct family from *Geopyxis*, so that the inclusion of the two fungi under the same genus appears almost absurd.

3. *Urnula terrestris* (Niessl)* Sacc. This is a small rather leathery fungus 2–3 mm. in diameter with a very short stalk. Copies

* Verh. Naturf. Ver. Brünn, 10: 63. 1872.

of Niessl's figures are given in Rehm, *l. c.* 990. The asci are about 124 μ long and 6 μ wide; the spores, 11–12 μ long and 4–5 μ wide. The cross section of *Urnula terrestris* (*fig. 3*) shows that here again there is no relation whatever with *Urnula Craterium;* the tissue is entirley pseudoparenchymatous, the excipulum being composed of two layers. The few outer rows are composed of cells about 11 μ in diameter with thick brown walls. The rest of the tissue is undifferentiated, so that we may call it excipulum with no marked hypothecium, or all hypothecium, restricting the term excipulum to these few rows of cells on the outside. Whatever we may call it, its character definitely separates it from a structure such as is found in *Urnula Craterium.* An additional fact pointing to the separation of the two species is one to which both Rehm and Lindau attach great importance in classification. Iodine colors the ascopores of *U. terrestris* blue, but does not those of *U. Craterium.*

Urnula terrestris as defined by Saccardo then, is not an *Urnula.* Niessl, in 1872, named the fungus *Podophacidium terrestre,* so that this old generic name, at least, we must restore. A point of interest, however, arises with regard to its specific name. In 1885 Boudier* established a genus *Melachroia* on *Peziza xanthomela* Pers. Schröter was the first to suspect the identity of the two fungi and called them *Podophacidium xanthomelan.* Rehm in his classification separates them, because the apothecium in *Urnula terrestris* splits into lobes, while in *Melachroia xanthomela* it remains nearly entire. In the letter before mentioned, however, Dr. Rehm says that he has no longer the least doubt that the two fungi are one and the same thing, and that the condition of the margin of the apothecium in *Urnula terrestris* is due merely to local conditions of growth. This view is substantiated by a comparison of the anatomy of the two forms. Dr. Rehm kindly sent specimens of both fungi which were sectioned as described above. The representation of *Urnula terrestris* (*fig. 3*) would do equally well for *Melachroia xanthomela;* the only difference revealed by the closest investigation was that the outer excipular portion was slightly thicker in the former fungus. This, however, may be regarded as purely accidental and of no significance. Consequently

* Bull. Soc. Myc. 1: 112.

we must adopt Schröter's nomenclature, and consider both *Urnula terrestris* and *Melachroia xanthomela* under the name of *Podophacidium xanthomelan*.

Since, then, the internal structure is very different from *Urnula Craterium*, and the splitting of the margin into lobes, which was Saccardo's chief reason for regarding this species as an *Urnula*, is an uncertain character, any relation between the two genera is seen to be absolutely unreal. To quote Dr. Rehm: "Dann schwindet allerdings die Verwandschaft mit *Urnula* Fr. völlig, und ist den zusammengehörigen beiden Pilzen eine andere systematische Stellung zu geben."

It might be well at this point, before the consideration of the next species, to decide what systematic position is to be assigned to the two species *Urnula Craterium* and *Podophacidium xanthomelan*. From the character of its tissue, the latter seems to belong in the Pezizaceae. Owing to the fact that the ascopore turns blue with iodine, and that the fungus is stalked, its affinities seem to be with *Tarzetta* and *Plicaria* in this family.

As to *Urnula Craterium*, it is my belief that it is to be placed among Saccardo's Dermateae or in the family Cenangiaceae following Lindau; the leathery texture of the apothecium, the prosenchymatous tissue and well developed hypothecium indicate this as its proper position. Whether or not a definite epithecium is present, as in most of the members of this family, could not be decided from sections of the dried specimens. The paraphyses do not seem to endure drying well, and were difficult to make out; so that these are represented (*fig. 2*) as somewhat reconstructed, and very probably do not quite accurately reproduce the condition in the fresh specimen. Even if an epithecium should prove absent, however, the Cenangiaceae appear to me to be the most satisfactory position, and, indeed, the only place for the fungus.

4. **Chorioactis Geaster.** (*Urnula Geaster* Peck.)* Finally we come to the species which was called by Peck *Urnula Geaster*, and which, since it is not an *Urnula*, I propose to call *Chorioactis*. This is a very large leathery fungus from 4–7 cm. in diameter, narrowed to a stem about 3 cm. long and 1–1.5 cm. thick. The apothecium splits into 4–6 rays, giving the plant an appearance

* Reg. Rep. **46**: 39. 1893.

very similar to a *Geaster*, so that Peck's specific name is an appropriate one. Both disc and stem are covered on the outside with a dense tomentum of soft brown hairs. The thickness of the apothecium is a striking characteristic; it sometimes reaches 2.5 mm. The outer layer of the apothecium is dark brown, the hymenium and flesh yellowish white; the asci are very large, 670 μ long; the spores are 49–60 μ long by 12–16 μ wide. The *Geaster*-like appearance of this fungus, the tough, leathery texture, the thickness of the disc, and the velvety tomentum which clothes the whole surface make of it an exceptionally characteristic and easily distinguishable genus and species. That it is not an *Urnula* seems to me just as evident from its external appearance as from an examination of its tissues. A comparison of internal characters shows, however, that there is no possible relation with *Urnula Craterium*. The tissue is made up wholly of large parenchymatous cells; those of the excipulum averaging 34 μ in diameter, those of the hypothecium 10–14 μ. The relative size of the cross sections of the various forms discussed can be seen from the fact that the sections of *Chorioactis Geaster* are magnified only thirty-five times, while all the others were magnified about two hundred times.

As to the position of *Chorioactis*, its entirely parenchymatous tissue will at once place it among the Pezizaceae. Following out Durand's scheme, its stipitate character, the tomentum and its elliptical spores indicate a relationship with *Plectania* and *Sarcoscypha* in this family. The genus *Chorioactis* will probably prove the most leathery in the whole family, but a comparison with *Sarcoscypha* and *Otidea* in this respect shows that among the Pezizaceae are to be included all gradations from a most fleshy brittle character, as in the majority of pezizaceous forms, to a texture as tough and leathery as that in the Cenangiaceae and other families.

To sum up briefly, then, the points brought out in this paper:

1. *Urnula Craterium* Fr. represents an entirely distinct genus not in any way related to *Geopyxis*. It is very probably to be placed in the family Cenangiaceae while *Geopyxis* is a member of the Pezizaceae.

2. *Urnula terrestris* (Niessl) Sacc. is not at all allied to *U. Craterium* and must consequently be removed from this genus. It is iden-

tical with *Melachroia xanthomela* Boud. and, following Schröter, must be called *Podophacidium xanthomelan*. Its position appears to be near *Tarzetta* in the Pezizaceae.

3. *Urnula Geaster* Peck forms a new genus, *Chorioactis*, distinct from *Urnula* and from all the other genera mentioned in this article. **Chorioactis Geaster** (Peck) seems to belong near *Plectania* and *Sarcoscypha* in the Pezizaceae.

Explanation of Plate 8

The illustrations were drawn from a magnification about two and one half times the reproduction appearing in the plate.

FIG. 1. Cross section of *Geopyxis carbonaria*, × 200.

FIG. 2. Cross section of *Urnula Craterium*, × 200..

FIG. 3. Cross section of *Podophacidium xanthomelan*, × 200.

FIG. 4. Cross section of *Chorioactis Geaster*, × 35.

Studies on the Rocky Mountain Flora—VII

By Per Axel Rydberg

Aquilegia Columbiana

Perennial with a short thick rootstock: stem 6–10 dm. high, glabrous or sparingly and finely pubescent above; basal leaves twice ternate; petioles 1–2 dm. long; segments rounded, obovate, 2–3 cm. long, more or less glaucous beneath, 2–3-cleft and deeply crenate at the apex; lower stem-leaves similar to the basal leaves, but with short winged petioles, the upper similar but often with larger segments: sepals and spurs very bright red; laminae yellowish: sepals ovate-lanceolate, acute, 15–25 mm. long, exceeding the spur, widely spreading or reflexed: lamina very short, scarcely 3 mm. long, truncate; spur 12–18 mm. long, thick, abruptly contracted about the middle: follicles erect, densely pubescent; styles about 12 mm. long.

This species is somewhat intermediate between *A. formosa* and *A. truncata* and has been mistaken for both. It has the habit, the spur and sepals of the former and the short truncate lamina of the latter.

Washington: Montesano, 1898, *A. A. & E. Gertrude Heller, 3936* (type in herb. N. Y. Bot. Garden); upper valley of the Nesqually, 1896, *O. D. Allen, 249;* 1889, *G. R. Vasey, 150;* Humptulips, 1895, *F. H. Lamb, 1180;* Puget Sound, *Wilkes Exped., 646.*

British Columbia: Banff, 1897, *Zoe W. Palmer.*

Alaska: Short Bay, 1895, *Gorman, 105;* Disenchantment Bay, *1892, F. Funston, 121.*

Idaho: Florida Mt., 1892, *A. Isabel Mulford.*

Aquilegia thalictrifolia

Perennial with a short rootstock: basal leaves twice ternate; petioles 1–2 dm. long; segments broadly obovate-cuneate, 2–3-cleft and crenate at the apex, 1–1.5 cm. long, bluish-green: stem 2–5 dm. high, glabrous below, finely viscid puberulent above: stem-leaves subsessile or very short-petioled, otherwise similar to the basal ones: flowers yellow: sepals 10–18 mm. long, ovate to ovate-lanceolate, acute: laminae of the petals 7–12 mm. long, truncate or rarely rounded at the apex; spur very slender from

the base, 4–5 cm. long: follicles without the styles, about 3 cm. long and 5 mm. wide, strongly reticulate and pubescent, strongly curved above.

This species is nearest related to *A. chrysantha* with which it has been confused, but differs in the smaller flowers, blunter sepals, smaller and bluer segments of the leaves and the more curved follicles. It grows at an altitude of 1500–3000 m.

COLORADO: Cañon City, 1873, *E. L. Greene* (type in herb. Columbia University); Colorado Springs, 1893, *De Alton Saunders;* Grand Cañon of the Arkansas, 1873, *Brandegee;* Bear Creek Cañon, 1892, *C. S. Sheldon.*

TEXAS: West Texas, 1888, *Nealley.*

ARIZONA: Mt. Humphrey, 1897, *R. E. Kunze.*

Aquilegia Eastwoodiae

Aquilegia ecalcarata Eastwood, Zoe, 2: 226. 1891. Not Hortul.; Steudel. 1841.

This has been regarded as a spurless form of *A. micrantha* Eastw., but the form of the terminal segments of the leaves is different from any American species, being rhombic in outline and acute.

Aquilegia oreophila

Aquilegia coerulea alpina A. Nelson, First Rep. Fl. Wyo. 78. 1896. Not *A. alpina* L. 1853; *Aquilegia coerulea* var. *flavescens* Jones, Cont. West. Bot. 8: 2. 1898. Not *A. flavescens* Wats. 1871.

This is evidently what Jones regards as *A. flavescens* Wats., but is not Watson's species, for he describes the spur as being curved. Specimens of both numbers cited by Watson, viz. *35* and *36*, are in the Columbia University herbarium and these as well as the plant cultivated under the name *A. flavescens* at Harvard have curved spurs and can not be referred as a variety to *A. coerulea.* Therefore, I can not see why Mr. Jones' *A. depauperata* should not pass into synonomy, being the same as the true *A. flavescens.* The flowers of *A. oreophila* resemble most those of *A. pubescens* Coville, but the habit is different and nearer *A. coerulea.*

Delphinium alpestre

A low cespitose perennial: stems several, about 1 dm. high, puberulent and viscid above, densely leafy; leaves digitately di-

vided into about 5 divisions, finely and sparingly puberulent when young, dark green; petioles 4–5 cm. long; divisions of the blades 1.5–2 cm. long, cuneate-obovate in outline, divided half-way into oblong mucronate lobes: inflorescence short and few-flowered; pedicels ascending, 1 cm. or less long, viscid; bractlets minute: sepals dark blue, oblong, obtuse or the upper acute, viscid-puberulent; spur 8–9 mm. long: upper petals blue and yellowish, 2-toothed at the apex; lateral petals 2-cleft; lobes lanceolate: follicles not seen.

This is not closely related to any of the American species. It has the cespitose habit of *D. glaucescens*, but is a much smaller plant. It grows among rocks at an altitude of 3300 m. or more.

COLORADO: Mountains northwest of Como, 1895, *Crandall & Cowen, 1848* (type in herb. State Agric. Coll., Colo.); West Spanish Peak, 1900, *Rydberg & Vreeland, 6218*.

Delphinium multiflorum

A tall perennial with a woody caudex; stem about 1 mm. high or more, viscid above, glabrate below: leaves palmately divided into 5–7 divisions, glabrous and glaucous, pubescent only on the margins and veins; petioles 1–2 dm. long, slightly dilated at the base; segments obovate-cuneate in outline, 5–7 cm. long, first cleft about half-way and then again cleft into lanceolate, ovate or oblong acute lobes: inflorescence long and dense, often branched; bracts linear; pedicels ascending, 1–1.5 cm. long, densely viscid-pubescent: bractlets small, linear, close under the calyx: sepals light blue with darker median lines or blotches towards the tips, oblong-oval, obtuse or the upper acutish, finely puberulent; spur thick, straight or slightly curved, 12–15 mm. long, almost horizontal: petals of the same color as the sepals; the lateral ones cleft only at the apex, often wavy-toothed: follicles erect, densely viscid-pubescent.

This is nearest related to *D. cuculatum* A. Nelson on one hand and to *D. occidentale* on the other. From the former it differs in the pubescence, which in *D. cuculatum* is strigose, in *D. multiflorum* viscid. *D. occidentale* has much darker flowers and more acute sepals. *D. multiflorum* grows along streams and in damp meadows or open woods at an altitude of 2000–2500 m.

WYOMING: Spread Creek, 1897, *F. Tweedy, 179* (type in herb. N. Y. Bot. Gard.); Yellowstone Lake, 1888, *R. S. Williams;* Laramie Mountains, 1899, *Charles Schuchut;* between Upper

Buffalo Fork and Du Noir River, 1899, *C. C. Curtis;* Snake River, 1899, *Aven & Elias Nelson, 6407.*

IDAHO: Henry's Lake, 1897, *Rydberg & Bessey, 4079.*

COLORADO: North Park, 1896, *C. F. Baker.*

Delphinium Brownii

Perennial: stem about 1 m. high, glabrous and shining throughout, simple: leaves palmately divided into about 5 divisions, puberulent; lower petioles 8–10 cm. long; divisions 4–6 cm. long, oblanceolate in outline, once to twice cleft into lanceolate, acute, somewhat spreading lobes: inflorescence a rather lax raceme; bracts linear; pedicels slender, 1–2 cm. long, almost erect, curved and twisted; upper portion sometimes slightly puberulent; bractlets linear-subulate, small, 3–4 mm. long: sepals dark blue or purple, oblong-oval, obtuse or the lower and upper acutish, 10–12 mm. long: lateral petals also blue or purplish; blade cleft only about one third its length; upper petals of the same color or paler, obliquely cuneate, acute; spur short and rather thick, 1 cm. or less long, straight and ascending: follicles erect, glabrous.

This is nearest related to *D. glaucum*, but differs in the puberulent leaves with narrower segments, the lax raceme with more erect pedicels and the darker flowers.

ALBERTA: Banff, 1893, *Addison Brown* (type in herb. Columbia University).

ALASKA: Porcupine River, 1891, *J. H. Turner.*

Delphinium elongatum

Tall perennial with a short woody caudex: stem glabrous and glaucous up to the inflorescence, which is slightly strigose: leaves digitately divided into about 7 divisions, glabrous and glaucous beneath; petioles fully 1 dm. long; divisions of the blade oblanceolate in outline, 5–7 cm. long, cleft into lanceolate, acute lobes: inflorescence strict and elongated; bracts small, linear, almost filiform; pedicels 1–2 cm. long, at first ascending, in fruit almost erect; bractlets minute, subulate: sepals and petals dark blue, the former oval, obtuse or acutish, about 1 cm. long; spur short, straight, about 12 mm. long: lateral petals cleft at the apex, more or less toothed: follicles erect, 12–15 mm. long, strigose-puberulent.

In some respects nearest to *D. glaucum*, but differing in the puberulent pod, strigose pubescence at least on the pedicels, and the narrower divisions and lobes of the leaves. It grows at an altitude of about 2000 m.

COLORADO: Larimer county, 1895, *Crandall & Cowen, 15* (type in herb. N. Y. Bot. Garden); Villa Grove, 1896, *F. Clements, 338;* Middle Park, 1861, *C. C. Parry, 85;* Baxton's Ranch, 1890, *Crandall, 1547.*

MONTANA: Lima, 1895, *Rydberg.*

Delphinium diversicolor

Perennial with a thick fleshy root, the branches of which are often fusiform: stem about 4 dm. high, simple, strict, densely viscid-pubescent above: leaves finely pubescent, palmately dissected into linear lobes; petioles of the lower leaves 3–5 cm. long, slightly dilated below; segments 1–3 cm. long, about 2 mm. wide: inflorescence a narrow raceme; pedicels .5–1 cm. long, or in fruit 1.5 cm., densely viscid, almost erect: sepals dark blue, oblong-oval, obtuse, 10–13 mm. long, slightly pubescent; spur almost straight, horizontal: petals all white with blue veins and yellowish below; the upper about 5 mm. long, obliquely spatulate, obtuse; the lateral ones slightly longer, curved; the blades deeply 2-cleft; each lobe of the form of one third of a circle: follicles densely hairy.

This species is perhaps nearest related to *D. simplex* and *D. Burkei.* From the former, it differs in white lateral petals and the pubescent leaves, and the latter is described as subscapose. The type was collected in a bog, at an altitude of 2000 m.

MONTANA: Rattlesnake Creek, Beaver Head county, 1887, *Frank Tweedy, 34* (type in herb. Columbia University).

Aconitum tenue

Perennial with small tubers about 8 mm. long and 4 mm. thick: stem very slender, about 3 dm. high: leaves few; the lower with petioles 5–8 cm. long, the uppermost subsessile: blades glabrous, thin, shining, almost pentagonal in outline, 5–7-divided to near the base; divisions rhombic in outline, 3-cleft and the lobes often again cleft, the ultimate divisions oblong-linear to linear-lanceolate, acute: inflorescence racemose, 2–6-flowered: pedicels erect and bent near the glabrous blue calyx: hood 15–18 mm. long, boat-shaped, slightly saccate, almost semicircular in outline; lateral sepals rounded ovate, only slightly oblique, 10–12 mm. long; lower sepals oblong, obtuse at the apex, 8–10 mm. long: fruit unknown.

The type was collected in a damp cañon among rocks at an altitude of about 2000 m. It is perhaps nearest related to the Alaskan *A. delphinifolium.*

SOUTH DAKOTA: Sylvan Lake, Black Hills, 1892, *P. A. Rydberg, 507* (type in herb. Columbia University).

Aconitum atrocyaneum

Perennial with thickened-fusiform roots: stem stout, 4–6 dm. high, leafy, glabrous below, densely glandular viscid and purplish above: lower leaves with petioles 5–10 cm. long; blades about 6 cm. wide, glabrous, pentagonal in outline, 5–7-divided to near the base; divisions rhombic-cuneate to oblanceolate, usually twice cleft; ultimate segments lanceolate acute; upper stem-leaves similar but with short petioles or those of the inflorescence lanceolate, toothed and often with recurved basal lobes: inflorescence racemose, many-flowered, leafy: pedicels 1–3 cm. long, erect, very viscid: flowers dark indigo blue, more or less pubescent: hood deeply saccate, helmet-shaped, about 18 mm. long, with the front line more or less concave: beak somewhat porrect, acuminate, the lower margins nearlyhorizontal: lateral sepals broadly rounded-ovate, somewhat oblique, 12–15 mm. long: lower sepals 9–12 mm. long, oblong, obtuse.

This species is perhaps closest related to *A. ramosum* A. Nelson, but the divisions of the leaves are broader and the hoods are different, having a porrect beak, while in *A. ramosum* the beak is short and directed downward. The flowers are also darker and the inflorescence more viscid. It grows at an attitude of 2,500–3,400 m.

COLORADO: Boreas, 1897, *C. S. Crandall* (type in herb. N. Y. Bot. Garden; cotypes in herb. State Agric. College, Colo.); mountains about Steamboat Springs, 1891, *C. S. Crandall;* near Ironton, 1899, *C. C. Curtis;* Cameron Pass, 1896, *C. F. Baker.*

UTAH: Uinta Mountains, 1873, *T. C. Porter.*

Aconitum porrectum

Perennial with thick fusiform roots: stem stout, 6–7 dm. high, leafy, glabrous below, densely viscid-pubescent above; basal leaves glabrous, with petioles about 1 dm. long; blades reniform-pentagonal in outline, 6–10 cm. wide, 5–7-divided to near the base; divisions rhombic or rhombic-oblanceolate, variously cleft above, cuneate at the base: inflorescence racemose or somewhat paniculate, not leafy; pedicels ascending, 1–3 cm. long: sepals dark blue, ciliate on the margins; hood very saccate, helmet-shaped; beak acuminate, porrect, horizontal or even slightly ascending, 15–18 mm. long; lateral sepals broadly obovate or semi-reniform,

about 12–14 mm. long, very oblique; lower sepals lanceolate or oblong, acute, 7–10 mm. long.

This is closely related to the preceding, but differs in the broader and less deeply divided divisions of the leaves, the shorter lower sepals, the more open and less leafy inflorescence, and the more oblique lateral sepals. It grows at an altitude of 2400–2800 m.

COLORADO: Coffee Pot Spring, 1894, *Crandall* (type in herb. N. Y. Bot. Garden; cotypes in herb. State Agric. College, Colo.); Graymount, 1892, *Crandall;* foothills, Larimer county, 1895, *Crandall & Cowen;* Arapahoe Pass, 1891, *Crandall, 26;* Lake City, 1881, *J. S. Newberry;* North Park, near Teller, 1884, *C. S. Sheldon.*

Aconitum glaberrimum

Perennial with a tap root: stem almost 1 m. high, perfectly glabrous: leaves 5-divided, thin, perfectly glabrous, the lower long-petioled; the uppermost subsessile; divisions oblanceolate to rhombic-oblanceolate in outline, 5–10 cm. long, cuneate and entire at the base, irregularly doubly cleft above; lobes or teeth lanceolate, acute or acuminate: inflorescence compound; branches and pedicels spreading or divergent, glabrous: flowers blue: lower sepals lanceolate, 12–15 mm. long; lateral ones very oblique, as broad as long, about 15 mm. each way, rounded, slightly reniform on the upper side; hood about 2 cm. long, deeply saccate, elongated helmet-shaped; beak long-attenuate, very porrect or even ascending.

The type specimen was included in *A. Columbianum* by Dr. Gray, his "Syn. Fl. N. Amer." label being on the sheet; but it is so unlike all other material of that species that I can not see the reason why it should be included therein. The perfectly glabrous stem, the branched inflorescence, the peculiar, deeply saccate hood and the slender porrect beak are characters not found in any other American aconite.

SOUTHERN UTAH, NORTHERN ARIZONA: 1877, *Dr. E. Palmer, 11* (type in herb. Columbia University).

Anemone tuberosa

Anemone sphenophylla Britton, Ann. N. Y. Acad. **6**: 224, in part. Not Poepp. 1827–29.

Perennial with a thick tuberous root, basal leaves with petioles

about 5 cm. long, twice ternate; divisions rhombic-cuneate in outline, ternately cleft and toothed; teeth oblong-ovate: scape 1–3 dm. high, perfectly glabrous below the involucre; peduncles finely appressed silky; involucral leaves similar to the basal ones, but short-petioled and with longer lobes and teeth; peduncle solitary or a second one with a smaller involucre: sepals white or purplish, 8–10, oblong-linear, 1–2 cm. long, finely silky: head of fruit ellipsoid, about 1 cm. thick and 2 cm. long: achenes densely woolly: style filiform, about 1.5 mm. long.

This is closely related to *A. sphenophylla* of Chili, but in that species the whole scape is decidedly pubescent with spreading hairs and the segments of the involucral leaves are narrower. The following species belong here:

ARIZONA: Sierra Tuscon, 1884, *C. G. Pringle* (type in herb. Columbia University); Fort Huachuca, 1892, *S. E. Wilcox.*

NEW MEXICO: Mountain near Las Cruces, 1895, *E. O. Wooton.*

UTAH: St. George, 1880, *M. E. Jones, 1607.*

CALIFORNIA: Panamint Mountains, 1891, *Coville & Funston, 500;* 1849 (locality not given), *Fremont.*

Anemone lithophila

Perennial with a short thick rootstock: basal leaves several, glabrous or nearly so, thickish, shining, somewhat glaucous; petioles 5–8 cm. long; blades ternate; divisions obovate-cuneate, about 3 cm. long, strongly veined, deeply 3-cleft, again cleft and toothed; the ultimate segments short, oblong-oblanceolate: scape 1–2 dm. high, sparingly pubescent with long silky hairs: involucral leaves subsessile or short-petioled; divisions similar to those of the basal leaves: sepals silky, ochroleucous, tinged with blue, 12–15 mm. long, broadly obovate or oval: achenes densely villous all over: style filiform, about 2 mm. long.

The type was growing with *A. parviflora* at an altitude of 1800 m. As none of the specimens there had well-developed fruit and the plant is intermediate between *A. parviflora* and *A. globosa* Nutt., which also grew in the neighborhood, this species may be a hybrid. The strong veins and shiny glaucous leaves suggest the former but the general leaf-form the latter, although the segments are broader and shorter and the leaves more glabrate. Watson's specimen, which resembles the type perfectly has fully developed fruit, however. The type was labelled *A. Tetonensis,*

which it resembles most in habit; but the achenes are wooly all over, not merely strigose on the back as in that species and the flowers are larger and lighter. The following specimens are to be referred here:

MONTANA: Little Belt Mountains, nine miles from Barker, 1896, *J. H. Flodman, 459* (type in herb. N. Y. Bot. Garden), and *463*; Lake Stanton, 1894, *R. S. Williams.*

UTAH: Uinta Mts., 1869, *S. Watson, 10.*

Anemone Piperi Britton

Perennial with a rather slender rootstock: stem 1.5–3 dm. high, slender, very sparingly appressed silky; basal leaves ternate, minutely appressed-puberulent when young, in age glabrous; petioles 1–2 dm. long; middle lobe rhombic-obovate or rhombic-cuneate, coarsely toothed above the middle, 2–7 cm. long; the lateral ones broader, obliquely ovate, 2-cleft to about the middle, coarsely toothed: involucral leaves similar, but the lobes usually narrower: petioles 1–3 mm. long: pedicel 2–5 cm. long, erect in fruit, sparingly appressed silky: sepals elliptic-obovate to oval, about 15 mm. long, 6–8 mm. wide, white, glabrous: achenes about 4 mm. long, densely short-pubescent, ellipsoid, slightly compressed, tapering to both ends: beak very short.

This has been included in *A. quinquefolia* and all specimens cited for that species from the Northwest may belong here. It differs, however, from that species in the form of the basal leaves, the erect pedicels and the short, almost straight beaks of the achenes.

IDAHO: Latah county, 1893, *C. V. Piper, 1469* (type in herb. Columbia University); Craig Mountain, 1892, *Sandberg, MacDougal & Heller, 194.*

WASHINGTON: Kamiac Butte, 1896, *A. D. E. Elmer, 393.*

Clematis Jonesii (Kuntze)

Clematis Douglasii var. *Jonesii* Kuntze, Verh. Bot. Ver. Brandenburg, **26**: 180. 1886.

Perennial with a thick rootstock or caudex: stems 3–6 dm. high, simple or later in the season branched, more or less woolly when young: leaves twice pinnately divided, 1–1.5 dm. long, villous when young, in age glabrate, rather firm, segments lanceolate to linear-lanceolate, often cleft, 1–5 cm. long, acutish: flowers nod-

ding: calyx campanulate, brown, more or less villous, especially near the margins; sepals 2–2.5 cm. long, ovate, acute or acuminate, upper half with a wavy dilated margin: achenes about 5 mm. long and 4 mm. wide, flattish, densely silky; tails of the achenes 4–5 cm. long, beautifully plumose throughout.

This is nearest related to *C. Douglasii*, with which it has been confused. It differs from that species in the dilated margins of the sepals, the distinctly petioled and less compound leaves. In the true *C. Douglasii* the upper and middle leaves are twice pinnately divided and subsessile, so that they with the first pair of primary divisions look as if verticillate. Kuntze's description of *C. Douglasii* var. *Jonesii* is so meager that nobody could know from it what he meant, but fortunately we have one of Jones' specimens. The following specimens belong to *C. Jonesii*.

COLORADO: Howe's Gulch, 1899, *W. F. M.;* Dolores (7300 ft.), 1892, *Crandall;* lat. 39°–41°, 1862, *Hall & Harbour, 2;* Howe's Gulch, 1893, *C. F. Baker;* near Boulder, 1892, *H. M. Patterson, 168;* Dixon Cañon, 1891, *J. H. Cowen, 368.*

UTAH: Uinta Mountains, 1869, *S. Watson, 1;* American Fork, 1880, *M. E. Jones, 1351.*

WYOMING: Headwater of Tongue River, Big Horn Mountains, 1898, *Frank Tweedy, 171.*

Clematis eriophora

Perennial, from a woody caudex: stems and leaves prominently white-villous, the former 3–5 dm. high, simple: leaves 5–10 cm. long, distinctly petioled, twice pinnately divided; ultimate segments narrowly linear, 1–3 cm. long, 1–2 mm. wide: flowers nodding; calyx villous, campanulate, about 3 cm. long; sepals oblong, obtuse, the upper third spreading, with a dilated margin: achenes oblong, about 6 mm. long and 3 mm. wide, silky, with a blunt ridge on each side; tails about 4 cm., beautifully plumose.

This is closely related to the preceding and to *C. Bakeri*, but differs from the former in the narrower leaf-segments, the obtuse and thicker sepals and the denser and more persistent pubescence, and from the latter in the longer leaf segments and the obtuse dilated sepals. It grows at an altitude of 1500–2000 m.

COLORADO: Vicinity of Horsetooth, 1896, *J. H. Cowen* (type in herb. N. Y. Bot. Garden; cotypes in herb. State Agric. College, Colo.); Foothills, Larimer county, 1893, *C. S. Crandall;* Colorado,

1870, Dr. *G. W. Hulse;* 1844, *Fremont, 567;* Pagosa, 1883, *Brandegee;* Golden City, 1871, *E. L. Greene;* Clear Creek, 1873, *John Wolf, 92;* Colorado Springs, 1900, *Rydberg & Vreeland, 6232;* Rist Cañon, 1890, *Crandall, 272;* 1893, *1379;* Horse-tooth Gulch, 1898, *Crandall.*

CLEMATIS WYETHII Nutt. Journ. Acad. Phila. **7**: 6 1834

I think that this species is distinct from *C. Douglasii* Hook., the leaves being never twice pinnately divided, having much broader segments and never being falsely verticillate as in that species. The specimens from Beaver Cañon, Idaho, cited in the synoptical flora under *C. Douglasii* var. *Scottii* and in Howell's flora of the Northwest under *C. Scottii* belongs undoubtedly here. A broad-leaved *C. Wyethii* and a narrow-leaved *C. Scottii* resemble each other very much and can be distinguished only by the flower, which in the former is campanulate with oblong-lanceolate sepals and in the latter rounded urn-shaped with broadly ovate sepals. *C. Wyethii* is common in Montana and northern Idaho. It is represented by the specimens cited under *C. Scottii* and some under *C. Douglasii* in my catalogue of the flora of Montana.

ATRAGENE OCCIDENTALIS Homem. Hort. Hafn. 1813: 520

Atragene Columbiana Nutt. Journ. Acad. **7**: 7. 1834; *Clematis Columbiana* Torr. & Gray, Fl. N. Am. **1**: 10. 1838; *Clematis verticillaris* var. *Columbiana* Gray. Syn. Fl. **1**: 8. 1895; *Clematis Pseudoatragene α normalis* Kuntze, Verh. Bot. Ver. Brandenburg, **26**: 160, in part, 1884; *C. alpina α occidentalis* 3 *typica* Kuntze, *l. c.* 161.

Dr. Gray adopted the name *occidentalis* as a varietal name for another species, and cites Homeman's plant as a synonym. It is very evident that the latter is the common plant of the Columbia Valley with simply ternate leaves and subentire leaflets, for Homeman expressedly describes them as entire. Dr. Kuntze was so far right that he placed *Atragene occidentalis* Homeman with *A. verticillaris*, although he made both forms of *Clematis alpina.* His revision of *Clematis* is far from good especially as to the West American species. The only distinction he makes between *C. pseudoatragene* and *C. alpina* is the absence or presence of stami-

nodia, a very unfortunate distinction, for in most of the West American forms both conditions exist. The filaments of the outer stamens are flattened and more or less petaloid. In some cases the outermost have no anthers (true staminodia), but often all are antheriferous. The present species is therefore placed in both species by Kuntze. *Atragene occidentalis* differs, however, from the eastern *A. Americana* in the fact that the staminodia as far as I know always are linear, while they are in *A. Americana* decidedly spatulate. *A. occidentalis* is common from British Columbia and the Canadian Rockies south to California and Colorado.

Atragene grosseserrata

Trailing or climbing over bushes: leaves ternate; petioles 5–8 cm. long; petiolules 1–2 cm. long; blades broadly ovate, oblique, somewhat cordate at the base, 3–4 cm. long, coarsely toothed and often somewhat lobed: peduncles 5–10 cm. long: sepals lanceolate, about 4 cm. long, 10–13 mm. wide, acute: staminodia about 18 mm. long, decidedly spatulate, a little exceeding the stamens: achenes small, sparingly hirsute: tails about 3 cm. long, plumose throughout.

This is closest related to the eastern *A. Americana;* but the leaves are deeper serrate and the sepals are longer, lanceolate, and resemble more those of *A. tenuiloba.* From *A. occidentalis* it differs in the spatulate staminodia, the shorter leaflets, which are coarsely serrate except the very base. In *A. occidentalis* the leaflets are entire or merely crenate above the middle.

IDAHO: Palouse county and about Lake Coeur d'Alene, 1892, *G. B. Aiton* (type in Herb. N. Y. Bot. Garden, flower).

WASHINGTON: Cascade Mountains, 1882, *F. Tweedy* (fruit).

Atragene repens (Kuntze)

Clematis alpina a occidentalis 2 repens Kuntze, Verh. Bot. Ver. Brandenberg, 27, 161, in part. 1884.

Plant trailing: leaves biternate, glabrous, firmer than in the two preceding: petioles 5–8 cm. long: secondary leaflets subsessile except the terminal, which is short-stalked, broadly ovate, coarsely toothed with broadly ovate teeth, 3–4 cm. long, abruptly short acuminate at the apex: peduncles over 1 dm. long: sepals ovate-lanceolate, about 4 cm. long, acute: staminodia linear: achenes about 5 mm. long, pubescent: tails about 4 cm. long, plumose throughout.

Dr. Kuntze's description of the subvariety *repens* is just as meaningless as the rest of his descriptions. He cites specimens, however, viz., *Jones* no. *1882* and *1887*. We have two sheets of each and they evidently do not belong together. No. 1882 in both the Columbia University and New York Botanical Garden herbaria are in fruit, have simply ternate leaves with subentire leaflets and must be referred to *A. occidentalis*. No. 1887 in flowers, on the contrary, has biternate leaves, and the leaflets are coarsely toothed. Dr. Kuntze's subvariety is, therefore, "eine zusammengesetzte" and according to some Germans, should be ruled out. After the part that belongs to *A. occidentalis* has been removed, I have adopted the name for the residue.

UTAH: American Fork, 1880, *M. E. Jones, 1887* (type in herb. N. Y. Bot. Gard.).

WYOMING: Wolf Creek Cañon, 1896, *Aven Nelson, 2294*, in part, the larger part belonging to *A. tenuiloba*.

Atragene pseudoalpina (Kuntze)

Atragene Ochotensis Gray, Pl. Fendl. 4. 1849. Not Pall. 1874; *A. alpina* var. *Ochotensis* A. Gray, Am. Jour. Sci. II. **33**: 241; *Clematis alpina* var. *Ochotensis* S. Wats. Bot. King Exp. **5**: 4; *C. alpina* var. *occidentalis* A. Gray; Powell, Geol. Surv. Dakota, 531. 1880. Not *Atragene occidentalis* Homem. 1813; *Clematis pseudoatragene* γ *pseudoalpina* Kuntze, Verh. Bot. Ver. Brandenburg, **26**: 160. 1884.

As stated above, the name *occidentalis* should be used for *A. Columbiana* Nutt. We are therefore obliged to adopt Kuntze's varietal name. In the Synoptical Flora *Clematis pseudoatragene* Kuntze is given as a synonym, but from the short description neither of the varieties α, β or δ can belong here. The var. α *normalis* is evidently partly *A. Americana* and partly *A. occidentalis* as here understood. The var. δ *subtriternata* is *A. tenuiloba* (A. Gray) Britton. What *Clematis pseudoatragene* var. β *Wenderothioides** is I do not know. In the Synoptical Flora the range is given as extending from New Mexico to Dakota and Washington. I have not seen any specimens from any station north of

* What a name! Translated it would mean: A variety of the false Atragene Virgin's Bower, resembling Mr. Wenderoth.

Colorado and Utah. All specimens referred here from higher latitudes belong to *A. tenuiloba*.

Ranunculus Utahensis

Perennial with a cluster of fibrous fleshy roots, glabrous: stems 1–2 dm. high, branched above; basal leaves petioled; petioles 2–5 cm. long; blades almost orbicular, rather thick, crenate or round-lobed: stem-leaves sessile, deeply cleft or divided into 4–5 oblong or elliptic, obtuse segments: sepals somewhat hairy, elliptic to obovate, at last reflexed: petals 4–5 mm. long, exceeding the sepals: head of fruit oblong; achenes glabrous; style rather short.

This species resembles most a depauperate *R. abortivus* in the leaves, but the petals are much larger and the head of fruit is oblong instead of spherical. It has gone under the name of *R. affinis* var. *leiocarpus*, but it is not that of Trautvetter, and is distinguished from all of those species which have been included in *R. affinis* by its thicker leaves and their lobing.

UTAH: Alta, Wasatch Mts., 1879, *M. E. Jones, 1130* (type in herb. Columbia University); Uinta Mts., 1873, *T. C. Porter*.

Ranunculus micropetalus (Greene)

Ranunculus affinis var. *micropetalus* Greene, Pittonia, **2**: 110. 1890.

An excellent species, very distinct from *R. affinis* Hook., and still more from *R. cardiophyllus* Hook., with which Davis associated it.

Ranunculus Helleri

Perennial with a short rootstock, perfectly glabrous: stem slender, 1–2 dm. high: basal leaves and lower cauline with slender petioles 2–5 cm. long; blades of the earlier basal leaves reniform, 3-cleft ⅔ or ¾ the distance to the base; middle division oblong, entire, the lateral ones with 3 ovate lobes; blades of the other basal leaves and the lower cauline divided to near the base into 3 cuneate divisions, 15–20 mm. long; the middle division 3-lobed, the lateral ones 4-lobed; stipules of lower cauline leaves conspicuous, rounded: upper cauline leaves sessile, divided unto the base into 2–4 linear-oblong divisions: flowers solitary: sepals oblong, obtuse, about 5 mm. long: petals oblong to obovate, golden yellow, 6–7 mm. long: head of fruit short-oblong or spherical: achenes turgid, almost spherical, 1.5 mm. long, glabrous: style slender and curved.

This species is nearest related to *R. Eschschotzii* and *R. alpeo-*

philus. In the former, which is very rare in the Rockies, the upper stem-leaves have broad and short lobes, which are elliptical to obovate; and in the latter the basal leaves are not reniform but almost orbicular in outline. *R. Helleri* grows in bogs at high altitudes.

IDAHO: Near Lake Pend d'Oreille, 1892, *Sandberg, MacDougal & Heller, 842* (type in herb. N. Y. Bot. Gard.).

WYOMING: Big Horn Mountain, 1899, *F. Tweedy, 2385*.

MONTANA: Sperry Glacier, 1901, *F. K. Vreeland, 1110*.

Ranunculus stenolobus

Perennial with a cluster of fibrous roots, perfectly glabrous: stems 1–3 from the same clump, 1–2 dm. high, usually branched: basal leaves and lower cauline petioled; petioles 4–10 cm. long; blades three times ternately dissected into almost linear segments, which are 6–15 mm. long and 1–3 mm. wide, usually somewhat narrowed at the base; the primary divisions distinctly petiolulate: sepals oval, 4–5 mm. long: petals obovate, 7–8 (rarely 9–11) mm. long: head of achene spherical or slightly oblong, about 6 mm. broad: achenes turgid, glabrous: style slender.

This species is somewhat intermediate between *R. adoneus* and *R. triternatus*, but the stem is more elongated and branched. Some of the specimens cited below have been referred to the former, but in that plant the stem is usually simple, the petals over 1 cm. long, cuneate-flabelliform and overlapping each other, the lobes of the leaves narrower and not narrowed downward. In the leaf-form and flowers it resembles more *R. triternatus*, but that grows in big clumps with numerous stems, and the segments are more decidedly petiolulate.

WYOMING: Headwaters of Cliff Creek, 1900, *C. C. Curtis* (type in herb. N. Y. Bot. Gard.).

UTAH: Alta, Wahsatch Mts., 1879, *M. E. Jones, 1104*; Wahsatch Mt., 1869, *S. Watson, 30*.

Papaver pygmaeum

A cespitose and scapose perennial; leaves all basal, numerous 2–3 cm. long; blade less than 1 cm. long, broadly ovate in outline, deeply cleft into rounded-oblong or obovate segments, sparingly hispid or glabrous: scape 4–6 cm. high, sparingly hirsute; so also the calyx, which is obovate in bud: petals yellow, 1 cm. or less long: pod obovoid, about 1 cm. long, densely bristly.

This species is nearly related to *P. radicatum* Rottb., but is a still smaller plant, with shorter, broader, less divided, less bristly

leaf-blades and smaller flowers. It resembles still more the European *P. Pyrenaicum*, which has larger petals, 1–2 cm. long, stamens much exceeding the ovary and spherical flower-buds.

MONTANA: Mountain above Stanton Lake, 1894, *R. S. Williams, 992* (type in herb. N. Y. Bot. Garden).

ALBERTA: Sheep Mountain, 1895, *John Macoun, 10269*; top of Rocky Mountains, 1881, *G. M. Dawson.*

Argemone rotundata

Stem stout, densely and strongly bristly, but otherwise glabrous: leaves oval in outline; the cauline ones sessile and broadly auricled, bristly, especially on the veins and margins, round-lobed: flowers short-pedicelled or subsessile: calyx very bristly; its horns erect or slightly spreading, bristly: petals white, fully 4 cm. long: pod ovoid, very bristly.

This has been mistaken for *A. hispida* Gray but is perhaps nearer related to *A. intermedia* and *A. platyceras*. From *A. hispida* it is easily distinguished by the absence of a finer indumentum and by the round-lobed leaves. The latter character also distinguishes it from the other two species mentioned. It is also much more bristly than the two. It grows at an altitude of 1500–1800 m.

NEVADA: Diamond Mountains, July, 1868, *S. Watson, 47* (type in herb. Columbia University).

UTAH: Utah Valley, 1869, *S. Watson, 49.*

Bicuculla occidentalis

Perennial with a very short rootstock bearing numerous tubers: scape and leaves perfectly glabrous; petioles of about 1.5 dm. long; blades twice ternate; the divisions twice pinnately divided or cleft into linear-oblong lobes, 1–2 cm. long, 3–5 mm. wide: scape about 3 dm. high: raceme simple: sepals oval, about 5 mm. long: petals pink; the outer about 1 cm. long; their spurs about 12 mm., divergent, forming with each other an angle of 90° or more; crest of the inner petals prominent; capsule fusiform, with the style about 1.5 cm. long.

This is nearest related to *B. cucullaria*, and has been confused with it, but has coarser foliage, more diverging and longer spurs, more prominent crest on the inner petals and the underground parts more gruinose and not scaly. Its range includes parts of Oregon, Washington and eastern Idaho, and it grows on shaded hillsides.

WASHINGTON: West Klickitat county, 1892, *W. N. Suksdorf* (type in herb. Columbia University).

The Conjugation of Spirogyra crassa Kg.

By Edwin Bingham Copeland

On an afternoon in September, 1900, the writer collected in a stagnant cut-off on Cheat River in West Virginia some *Spirogyra* so large that its conjugation was very evident to the naked eye. It was fixed in Flemming's fluid and preserved in alcohol. When it was examined and determined later, preliminary to class use, it was found to have some characteristics that are probably worth reporting.

Different species of *Spirogyra* vary in the intensity with which they possess distinct sexuality, as male or female plants. In all of them the cells show a difference in behavior, in that one is recipient, the other active, which is a marked advance over related genera in which the zygospore is formed midway between the gametes. But in some species the cells of a single filament conjugate in pairs, the conjugating tube passing around the transverse wall; in this case the filament as a whole is without sex. When the conjugation is between the cells of parallel filaments it is usually altogether in one direction, one filament acting as female and the other as male. But in such cases filaments sometimes occur which if traced far enough are found to bend about onto, and conjugate with, themselves, being female in one part, male in another. Such cases suggest that where a distinction of the sexes is just beginning to appear, sex may be a relative quality; if one part of a filament can be male with reference to another part as female, why might not a filament act as male with reference to one of its neighbors, but female with reference to another. In this *S. crassa* material sex is a positive quality of the filament. I have examined a great number of instances of polygamy and polyandry, cases in which a long filament conjugated at different places along its length with several others. I have never found a filament conjugating with itself, nor a single instance of a filament whose sex was not constant in its numerous alliances. Often three filaments were in contact, each with both the others; one would conjugate with both others indiscriminately, all the cells of both the others

starting to form conjugating tubes with it; but the two of like sex never stimulated each other even enough to make the tubes start to grow. The filaments are then completely dioecious, and their sex must be determined in the zygospore. Complete dioecism is a higher degree of sexuality than would be anticipated in plants whose gametes are not visibly different* except in their part in conjugation.

In much higher plants, likewise dioecious, the sex is not always as fixed as it seems here: thus Lesquereux and James † say of *Atrichum undulatum* Beauv.: "This species is dioecious, but sometimes the young male plant produces from the center of the flower an innovation bearing female flowers and thus the male plant is transformed into a fertile one."

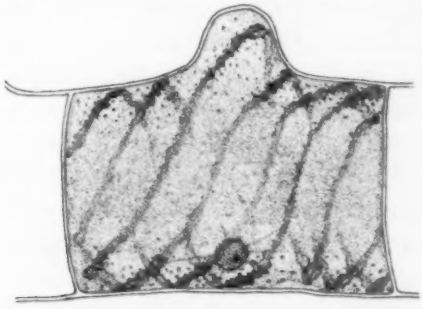
In the cells of the vegetative filaments the nuclei were large and centrally placed, the entire contents of the cells reasonably clear, and no unusual bodies to be seen in the chloroplasts. In cells which had progressed in conjugation to the meeting of the tubes there were usually some black granules in the chlorophyll bands, the body of the cell remaining as clear as ever. Where two filaments of one sex conjugated with one of the other, or where one filament of a pair had shorter cells than the other, there were cells which tried to conjugate but failed: sôme of these merely started to put out a conjugating tube, at other times this stimulated the development of a tube to meet it. In all of these cells the contents was discolored by the presence of distinct granules and of a diffused opacity. The shade varied from pale brown to deep black. The failure to conjugate has interfered in some way with the normal metabolism of the cells. Very likely it is that plastic matter intended for use in conjugation has accumulated as oil and has been blackened by the osmic acid. But it occurs in cells whose conjugating tube has completely formed. The pen drawing is made from a cell which failed to conjugate, and is drawn a little lighter in shade than is natural.

The position of the nucleus in conjugating cells was remarkable. A large part of my material was fixed at about the stage in

* Kny (Wandtafeln, Text, 11) says that the sex of filaments of his material—a large, not certainly identified species—was distinguishable by the shape of the cells, before conjugation began.

† Mosses of North America, 256.

conjugation when the wall between the tubes is absorbed: in all of it, in this stage and somewhat earlier, the nucleus was very constantly to be found close to the outer wall on the side *opposite* the conjugating tube. This could be seen in almost every conjugating cell. In the cells which failed to find mates the nucleus was more often invisible or obscured; but sometimes it was very evident, as in the cell drawn. In this position the nucleus is rather smaller and much less conspicuous than in vegetative cells.* This position of the nucleus is the opposite of that usually assumed in cells with local-



ized growth.† As is suggested in a recent paper by Miehe,‡ the central position of the nucleus in young and active cells, instead of a lateral one, even when growth is more or less localized, is easily understood in consideration of the various functions of the nucleus. But this is the first instance known to me of a nucleus that moved to the opposite wall. This species, *S. crassa*, has been studied in the same connection by Gerassimoff,§ but not during conjugation.

* Strasburger (Befructung und Zelltheilung, Jena, 5, 1878) says that early in the conjugation of *S. quinina* the nuclei become pale and disappear.

† Haberlandt. Ueber die Beziehungen zwischen Function und Lage des Zellkernes bei den Pflanzen. Jena, 1887. Physiologische Pflanzenanatomie. 2d Ed. 23–24. 1896.

‡ Ueber Wanderung des pflanzlichen Zellkernes, Flora, 88: 105–142. 1901.

§ Ueber die Lage und die Function des Zellkernes. Moscow, 1900.

A novel Seed Planter

By David Griffiths

Much interest naturally attaches to a desert flora. In a humid region where the soil cover is maintained throughout the year, and the growing season continues for six or more months, there occurs such a gradual succession of species that the transition from spring to summer or summer to autumn is so gradual as to escape attention. The most striking change is the spring awakening which is dependent upon the return of invigorating higher temperature. In a desert region, however, the changes which occur are much more sudden and striking. A change from a naked surface dotted here and there by a stray sinuous shrub or a spiny cactus to a literal flower garden so dense and extensive as to be recognizable by the brilliancy of its golden hue a score of miles distant, is something which impresses the uninitiated with peculiar force. What the characteristics of this vegetation which comes so rapidly and dries up and blows away as it were in such a remarkably short time are: how it survives the long droughts and the intense heat; what the contrivances are by which it propagates itself; how it successfully maintains itself against such trying conditions are considerations of much scientific interest and growing economic importance. It is the purpose of this paper to record some observations on one contrivance by which one desert annual is able to cope more successfully with the conditions in which it finds itself.

While upon the deserts of southern Arizona during the winter of 1900–1901, it was often a matter of wonder to me how the multitude of seedlings which were springing up all over the mesa became established, and how the seeds succeeded in remaining on surfaces which had apparently been deprived of every vestige of tilth by the erosive action of fierce destructive showers whose only effect appeared to be the carrying away of everything not actually anchored to the subsoil. In such localities, however, in the vicinity of Tucson on areas where there appeared to be nothing left but the undisturbed hardpan subsoil there occurred a profuse growth of

Plantago fastigiata Morris, the "Indian wheat" of the region. How it was possible for these seedlings to establish themselves in such situations were matters for speculation only. In March the crop of this plant was in its prime and in many localities covered the ground almost completely and yielded as high as a ton of air-dry substance per acre. The crop of seed was truly wonderful and upon the maturity of the plant in April and the advent of the dry weather of May it became strewn all over the surface of the mesa. It was not, however, particularly conspicuous until after a shower of rain in the latter part of May. Although a light shower it was quite vigorous for a short time and caused water to run freely on the mesa, resulting in much of the seed strewn over the surface being washed into cattle tracks, gopher holes, and other surface depressions. It was then that an explanation of the wonderful "sticking qualities" of the seed was offered.

The seeds of the plantains are altogether too common to require any extended description. Those of this species, like all others with which the writer is familiar, are covered with a compact glossy or often white coating which absorbs water, expands wonderfully and becomes mucilaginous when an opportunity is offered. This coating of mucilage, as it is usually called, is considerably more pronounced in this and some other dryland species than in those which grow in more humid regions. When the coating has absorbed water to its full capacity, it loses any opacity which it may have due to the presence of air in the dried mucilage, and the whole seed and its coating assumes the appearance of a particle of jelly inclosing an oval hemilenticular particle in its center. When examined a little more closely, however, the coating is seen to have a definite structure. It presents a distinct radial appearance with the rays more or less regular in arrangement and formed by a greater concentration of matter than the intervening spaces.

When examining the plant after the shower of rain in May, the first things to attract attention were the masses of seed which had collected in the depressions. At first these masses were simply a mixture of seed, mucilage and débris from the general surface of the desert. After a time the seed separated largely from the refuse and a crust was formed both above and below. The upper one

was formed by the rapid evaporation and the lower one by mixing with the drier earth below which abstracted water and furnished particles of sand to adhere to and mix with the mucilage making the mass more firm. In this way cakes were formed with a mucilaginous center and firm crusts on either side. All of the water soon evaporated, however, leaving a cake of seed and débris in every depression. These often measured two feet in length by three inches in thickness in the center. There were places on the mesa to the southeast of the University at Tucson where one could pick out an acre of ground which was one fourth covered with cakes of this seed. As the water evaporated and the cakes became thoroughly dried they presented a peculiar appearance indeed, for they naturally curled up at the edges. The surface of the mesa presented an appearance not unlike the surface of a table with photographic prints laid upon it to dry. It is quite probable that all of the seeds in these cakes were destroyed. At least one would naturally expect this result although an opportunity has not been given for actually observing their fate.

There were of course plenty of seeds which were not washed together and it is to the behavior of these that the greatest interest attaches, for upon them the next year's crop is dependent. After the surface of the ground had dried nearly every seed which had remained isolated was sunken in a little pit in the ground, the walls and bottom of which were made rigid by the hardened mucilage. The seed was inclosed in a little cup, as it were, sunken into the earth—not deeply—but evidently sunken to a depth about equal to the distance between its parallel side. The pit had a diameter of about three times that of the seed.

The agent which caused the sinking of the seed was evidently the mucilage, but how such a particle of lifeless matter could accomplish this result so nicely did not appear clear. The seed was as effectually sunken as though it had been done by human hands. It was not covered, but this would inevitably be accomplished in the succeeding dry months by the natural abrasion of the surface of the soil. The cup would be filled by silt and sand effectually completing the process of planting the seed.

Several experiments have been performed for the purpose of determining the mechanism by which this burial of the seed is

accomplished. Sowings of seed collected in large quantities last spring have been made on several surfaces. Glass, tissue paper, blotting paper, clean sifted building sand, sand of a roadbed at Takoma Park, D. C., and some of the finer clayey soils have been used as seed beds. After being scattered the seed together with the substratum were moistened sufficiently to thoroughly distend the mucilaginous coatings. The behavior of the mucilage on the different surfaces when compared appears to me to indicate clearly its mechanical behavior in sinking the seed.

Upon the glass surface not only was the structure of the mucilaginous covering easily observed, but it was demonstrated that upon drying it does not return to its original position around the seed. It flattens out on the support instead, serving in this way to attach the seed very firmly to the surface. When dried the seed will therefore be firmly fastened to the glass and have surrounding it two distinct zones. The inner zone will have an irregular radial striation and a dense heavy appearance indicating that the greater amount of the mucilage is concentrated there. It has the appearance of having been thrown into minute radial folds in drying. The outer zone is much wider, contains much less of the mucilaginous substance but has no well-marked structure. Its outer as well as its inner boundary is very irregular and there are in it very faint irregular and indistinct radial thickenings. When the seed is forcibly removed from the glass both zones may accompany it, but usually the outer one remains attached to the glass.

When seed sown on blotting paper has dried, only a little of the inner zone of dried mucilage is apparent, the outer one being invisible on account of having sunken into the surface of the paper. When the seed is forcibly removed only a part of the inner zone of dry mucilage accompanies it, the outer one invariably remaining attached to the paper. Of course some of the paper usually accompanies the seed which is removed.

On tissue paper the appearance does not differ materially from blotting paper, the outer zone here again being sunken into the fibers. There is one decided difference, however. The paper has a tendency to wrinkle parallel to the long axis of the seed, leaving it in a trough of the folds with the elevations on either side.

The seed sown on clean building sand presented when dry a

very different appearance from that on the deserts of Arizona. Instead of being sunken in a small pit they simply form the center of little wads of sand which are firmly attached to them by the adhesiveness of the mucilage. The seeds were slightly sunken but there was no sign of pits in the sand.

When the seed sown on the sand of a roadbed had dried, some of it had exactly the same appearance as that upon the clean building sand, while the remainder presented exactly the same appearance as that upon the hard limy soils in the vicinity of Tucson, Arizona.

That sown on the hard smooth surface, of reasonably stiff clayey soil differed in no way when dry from that described above for its natural habitat. The pits with the seed seated in them were as perfectly formed as one could wish to see them.

Bringing the phenomena of these different experiments together, it appears to me that we can formulate an explanation of the action of the mucilage in the sinking of the seed and the forming of the pit into which it gravitates, or rather is both pushed and pulled. When the mucilaginous coating is completely distended it measures about 5 x 7 mm. in its greatest horizontal diameters. The outer portion of the coating, especially, flattens out wonderfully and penetrates the substratum as shown by the experiments on paper. When the process of desiccation begins, the soil being porous will give up its moisture more readily both to the underlying strata, which are almost invariably dry in Arizona, as well as to the atmosphere than the mucilaginous seed coat.

This condition together with the fact that the outer layers lose moisture much more rapidly than those close to the seed results in drying and fastening the outer edge which has flattened out upon the soil and also sunken into it, as well as the lower surface, firmly to the soil particles. As soon as this occurs a tension is set up which would naturally be toward the center—that is the outer contracting layers would crowd the inner ones—but having become anchored to the soil particles and rendered rigid by drying, and having only a loose connection with the undried inner layers, the pull is outward in all directions. The underside of the mucilaginous particle in contact with the soil has also lost moisture, but here to a much less degree than the outer edges in better contact

with the air. The lower layers are the dryest and, therefore, soon become attached to particles of earth, we will say 2 mm. below the surface. As drying proceeds the upper surface in contact with the air will sink, and the lower anchored to the particles below the surface will exercise a downward pull. The lower surface is drying from below so that successively higher particles are being subjected to the downward strain. There are, therefore, three forces acting, the first horizontal and outward caused by the anchoring of the outer edge of the flattened particle of mucilage, and the second downward owing to the contraction of the upper layers exposed to the air. The third acts from above downward and is the result of loss of water by the lower layers of mucilage. It should be stated that the seed is comparatively free from these three forces, for it is in the center of the mucilaginous particle which is the last to solidify. The resultant of these three forces is evidently a downward one which effects the solidifying of the soil below and immediately surrounding the seed to a depth of about 0.5 mm., or equal to the distance between its flat surfaces. All that is now necessary in order to have the planting completed, is to have a gust of wind or a shower of rain pack the soil around the seed in its little depression.

To summarize, therefore, it appears that the function of the mucilage is the burial of the seed and that this is accomplished by the tension set up owing to the contraction of the expanded mucilage which has become firmly attached around its outer and lower edges to the particles of soil into which it has penetrated, resulting in a compacting of the soil immediately below the seed and its coat so as to form a pit into which the seed is forced. The cup-shaped depression is subsequently filled with earth by entirely external influences.

On the Arizona deserts this phenomenon is not confined to the ordinary soils of the mesa, but may frequently be observed on the hard surface of a roadbed. To what extent this principle is applicable to flax, pepperwort and other mucilaginous seeds has not, so far as the writer knows, been investigated.

Notes on the comparative Resistance to high Temperatures of the Spores and Mycelium of certain Fungi

By Abigail A. O'Brien

It is a well-known fact that the spores of bacteria are more resistant to heat than are the vegetative cells. It has been generally believed that the same is true of fungi, that is, that the spore is better able to resist a high temperature than is the mycelium. The method of fractional sterilization has in fact been based upon that belief. Professor B. M. Duggar suggested to me that in the case of some fungi, especially those with thin-walled spores, the mycelium might be at least as resistant to moist heat as are the spores. His work on *Sporotrichum globuliferum* * indicated that with this fungus such is the case. The following series of experiments on five representative fungi, carried on under his directions, confirms his results in general.

Methods.—The fungi experimented upon were *Aspergillus flavus*, *Botrytis vulgaris*, *Rhizopus nigricans*, *Sterigmatocystis nigra* and *Penicillium glaucum*. They were grown upon beet cylinders in test-tubes. The mycelium used in these experiments was taken from the culture tubes within two and one half days after the fungus had begun to grow and before any spores had formed. The spores used in the experiments were from one to two weeks old. The spores were placed in sterilized test-tubes filled to the height of about one inch with beet decoction. The tubes were then put in a boiler heated to the desired temperature and left for five, ten, fifteen, thirty or sixty minutes. After the exposures, drop cultures of the decoction in the tubes were made in Van Tieghem cells. The spores of *Aspergillus* and *Sterigmatocystis* showed a tendency to float on the surface of the liquid and to collect in small masses. It was therefore found necessary to immerse them in distilled water before putting them in the decoction. In the experiments with the mycelium, a bit of the hyphal mass was removed from the plug with a sterilized needle, and was then treated exactly as the spores were. The cultures were in all cases

* Bot. Gazette, 31 : 38–66. Ja. 1901.

accompanied by checks, which gave uniform growth and are therefore not recorded. The cultures were usually examined twenty-four hours after they were made, and again within two or three days. Results were recorded after the first examination, but additions were sometimes made upon later examination.

The figures in the table indicate the percentage of growth. In the case of the mycelium it was found impossible to indicate the new growth by exact per cents., hence fresh growth is indicated in all cases by (g) which is recorded only where vigorous fresh growth appeared on all sides of the bit of mycelium.

No.	Temperature °C.	Fungus	Spores					Mycelium				
			Time of Exposure in Minutes					Time of Exposure in Minutes				
			5	10	15	30	60	5	10	15	30	60
			Percentage of Germination Growth									
1	45	Botrytis.	all	90	40	50	2					
2		Rhizopus.	all	20	30	40	5					
3	47	Aspergillus.	98	98	98	98	80					
4		Botrytis.	50–75		5–15	10	0					
5		Rhizopus.	50–75	25	10	20	10					
6		Sterigmatocystis.				75	100					
7	50	Aspergillus.	90	40	10	0	0				g	g
8		Botrytis.	65	2	1 or 2 spores	1 or 2 spores	2				0	0
9		Rhizopus.	1 or 2 spores	45	15	0	0				g	g
10		Sterigmatocystis.	98	90	40	0	4				g	g
11	52	Aspergillus.	90	80	35			g	g	g		
12		Botrytis.	20	10	1			g	g	g		
13		Rhizopus.	1–2	2–3	0			g	g	g		
14		Sterigmatocystis.	all	90	80	0		g	g	g		
15	53	Aspergillus.						g	g	g		
16		Botrytis.						g	g	g		
17	55	Aspergillus.	0	0	0	0	0	0	0	0		
18		Botrytis.						0	0	0		
19		Rhizopus.						0	0	0		
20		Sterigmatocystis.	2	1	0	0	0	g	0	0		
21	60	Penicillium.	50	20–50	10–15	5	5	g	g	g	g	0
22	65	Penicillium.	0	0	0	0		g	g	g	g	g

Certain experiments were omitted, hence blank spaces appear in the table. For instance it was found that the mycelium of all the fungi except *Botrytis* gave vigorous fresh growth at 50° for the two longer exposures, 30 and 60 minutes, hence it is unnecessary to try it at lower temperatures. Also *Penicillium*, both spores and mycelium, gave vigorous growth at 55°, and was, therefore, omitted from the experiments at lower temperatures.

It will be noticed that the percentage of spores germinated does not always vary inversely as the length of the time of exposure, as would be expected. This discrepancy, however, can only be accounted for by the variation in resistance of individual spores.

The results given in the table, especially those of experiments 7, 9, 10, 12, 13, 22, seem to warrant the conclusion that in the five fungi studied, the spore, that is, the conidium, is no more resistant to moist heat than is the mycelium.

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Hesperaster nudus (Pursh) Cockerell and its Allies

By George E. Osterhout

There are four species of *Hesperaster* (*Mentzelia*) found on the plains and in the mountains of Colorado which have large white flowers. They are all vespertine as to the time of blooming. The largest flowered one is *Hesperaster decapetalus* (Sims) Cockerell (*Mentzelia decapetala* Urb. & Gil.). The size of the flowers so distinguish it that it is not likely to be mistaken for any of the others. *H. Rusbyi* (Wooton) Cockerell (*Mentzelia Rusbyi*) was described by Professor E. O. Wooton in the Bulletin of the Torrey Botanical Club, **25**: 261. This is a large plant having the upper leaves sessile by a broad base and acuminate. The flowers are smaller than those of the other species and the capsule only slightly foliose at base. It surely is not an annual as Professor Wooton suggests but seems to be about as enduring as the other species.

There are yet two species which have usually been referred to *Mentzelia nuda*. One of these is strict in manner of growth, branching at the middle or toward the summit; the leaves are decidedly hispid on both surfaces; the capsule has pinnatifid bracts at its base, is foliose at base, and the seeds are subovate. It grows on the plains. The other is a more branching plant; the leaves are not so hispid on the upper surface, the capsule is *not* foliose at base; the seeds are round and wing-margined.

Which of these, if either, is the *Bartonia nuda* Pursh? Some help may be had in solving the problem from the early descriptions. Nuttall says of *Bartonia nuda*, "capsule naked." This fact contrasted it with his *Bartonia ornata* (*i. e.*, *H. decapetalus*) which has the "base of the capsule foliose," and probably suggested the name *nuda*. The description in Torrey and Gray's Flora is drawn from that of Nuttall and adds nothing of notes. But there is a specimen of Nuttall's plant yet in the herbarium of the Philadelphia Academy of Sciences, and the name *Bartonia nuda* is in Nuttall's handwriting. I am greatly indebted to Mr. Alex. MacElwee for comparing specimens with Nuttall's plant and for facts concerning it.

While this specimen is only of the top of a plant, having a few leaves and flowers it agrees with the description in that the capsule is not foliose at base. It also has the appearance of belonging to a branched and spreading plant. The first of the plants mentioned above then, is not of this species, but the second one agrees quite well with the description and plant of Nuttall and, if either of them, is the *Mentzelia nuda* (Pursh) T. & G. It seems to be found mostly along the foothills in rocky, gravelly soil in the vicinity of streams; and Nuttall says of *Bartonia nuda* "near the Great Bend of the Missouri on gravelly hills."

For the first of the species above mentioned then a description is offered.

Hesperaster stictus sp. nov.

Seemingly a perennial, certainly more enduring than a biennial, the stem white and hispid, 0.5–1 m. high, fastigiate and somewhat corymbose, leafy, the leaves gradually reduced upward: leaves oblong, about 1 dm. long toward the base of the stem, the lower on short petioles, the upper sessile, sinuate-toothed, obtuse, hispid on both surfaces, the short barbs pustular at base: capsule 2–3 cm. long, hispid, having pinnatifid acuminate bracts at its base: calyx lobes deltoid-acuminate: petals 10, of the same size, 2.5–3.5 cm. long, tapering to a broad claw of about one third its length: many filaments petaloid: seeds subovate, 4–5 mm. long, wing-margined.

Quite generally distributed on the plains east of the mountains in Colorado and probably the adjoining states. Specimens collected at New Windsor, Weld county, Colo., July 22, 1901, no. 2488, may be considered typical. Judging from the description this is the *Mentzelia nuda* of Porter and Coulter's Flora of Colorado, and many of the plants which have been collected on the plains are quite likely the same.

The genus to which the plants of this article belong was first published by Sims in 1812 as *Bartonia*. Torrey and Gray in their Flora of 1838–1840 included it in *Mentzelia;* but Professor T. D. A. Cockerell has republished it under the name *Hesperaster*, in *Torreya*, December, 1901. As this will probably be generally adopted it will be necessary to transfer another species recently described, *Mentzelia speciosa* Osterhout, Bull. Torrey Club, **28**: 689, and overlooked by Cockerell. This will become **Hesperaster speciosus.**

NEW WINDSOR, COLO.

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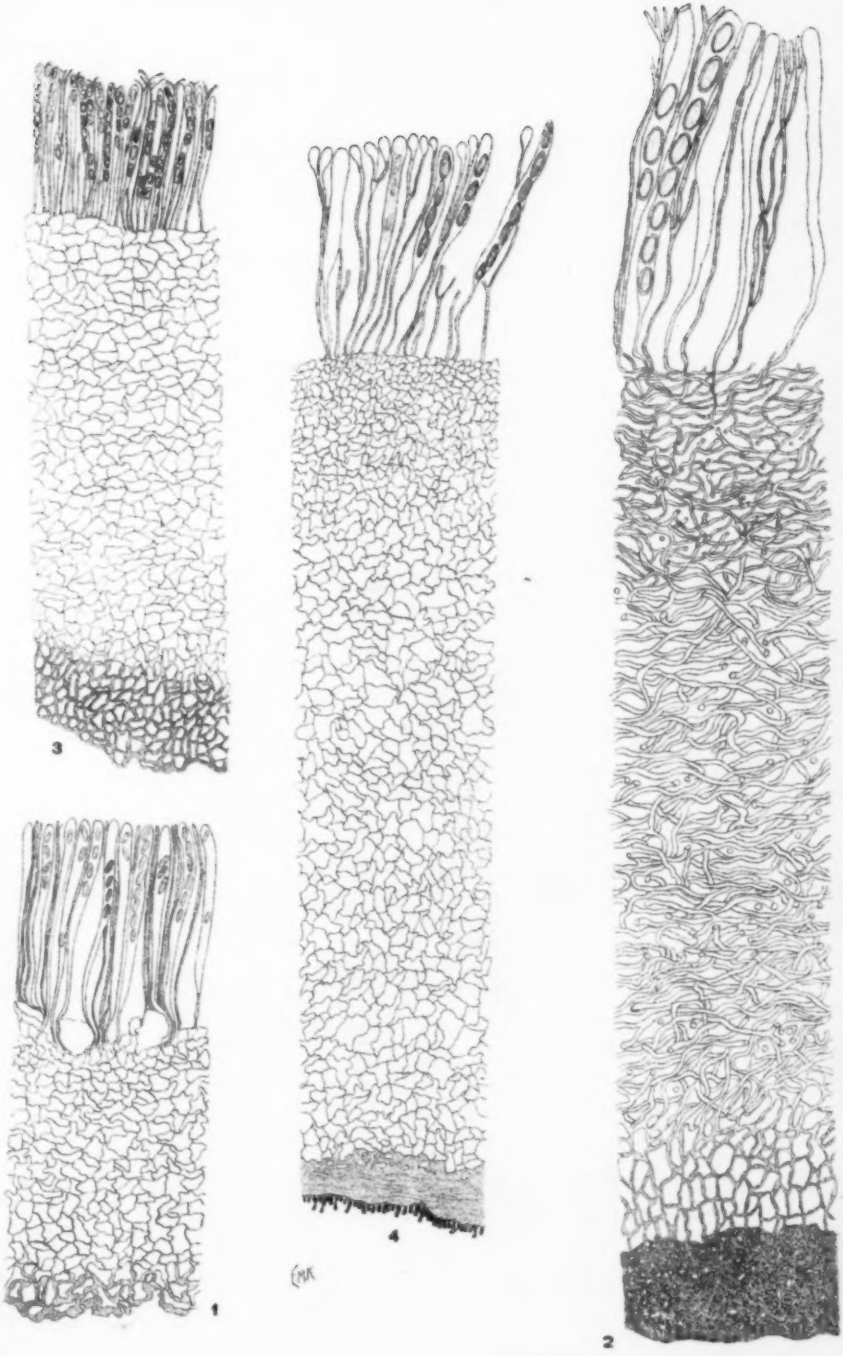

URNULA, GEOPYXIS AND CHORIOACTIS